State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Northern District

SOME PHYSICAL, CHEMICAL, AND BIOLOGICAL CHARACTERISTICS OF THE EEL RIVER ESTUARY

<u>Memorandum Report</u>

June 1977

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Northern District

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INTRODUCTION

Estuaries have long been assumed to be important as nursery and residence areas for several species of marine and freshwater fish. Their greatest contribution in this regard may be in providing food and habitat for juvenile salmon and steelhead migrants as they undergo the physiological changes needed to adapt to the marine environment.

The Eel River estuary is no exception. Many studies have been initiated to determine the importance of this estuary in providing food and habitat for both adult and juvenile fishes (Murphy and DeWitt 1951), Monroe and Reynolds 1974, Smith et al. 1974, Puckett 1977). Many of these reports have merely been lists of fishes found in the estuary, and have not contributed much information about the role of this estuary. Monroe and Reynolds (1974) discuss the habitat surrounding the estuary, as well as the bird, mammal, reptile, and amphibian resources. Zooplankton found in the Eel River estuary was briefly investigated by Stokes (1970). Except for brief mention in some reports of a few larger invertebrates (Monroe and Reynolds 1974, Puckett 1977), little is known about this part of the esturine biota.

A study was initiated in 1973 to determine the invertebrate and periphyton assemblages, and the physical and chemical characteristics of the Eel River estuary. Due to termination of funding, this study was concluded during the 1976 fiscal year.

DESCRIPTION OF STUDY AREA

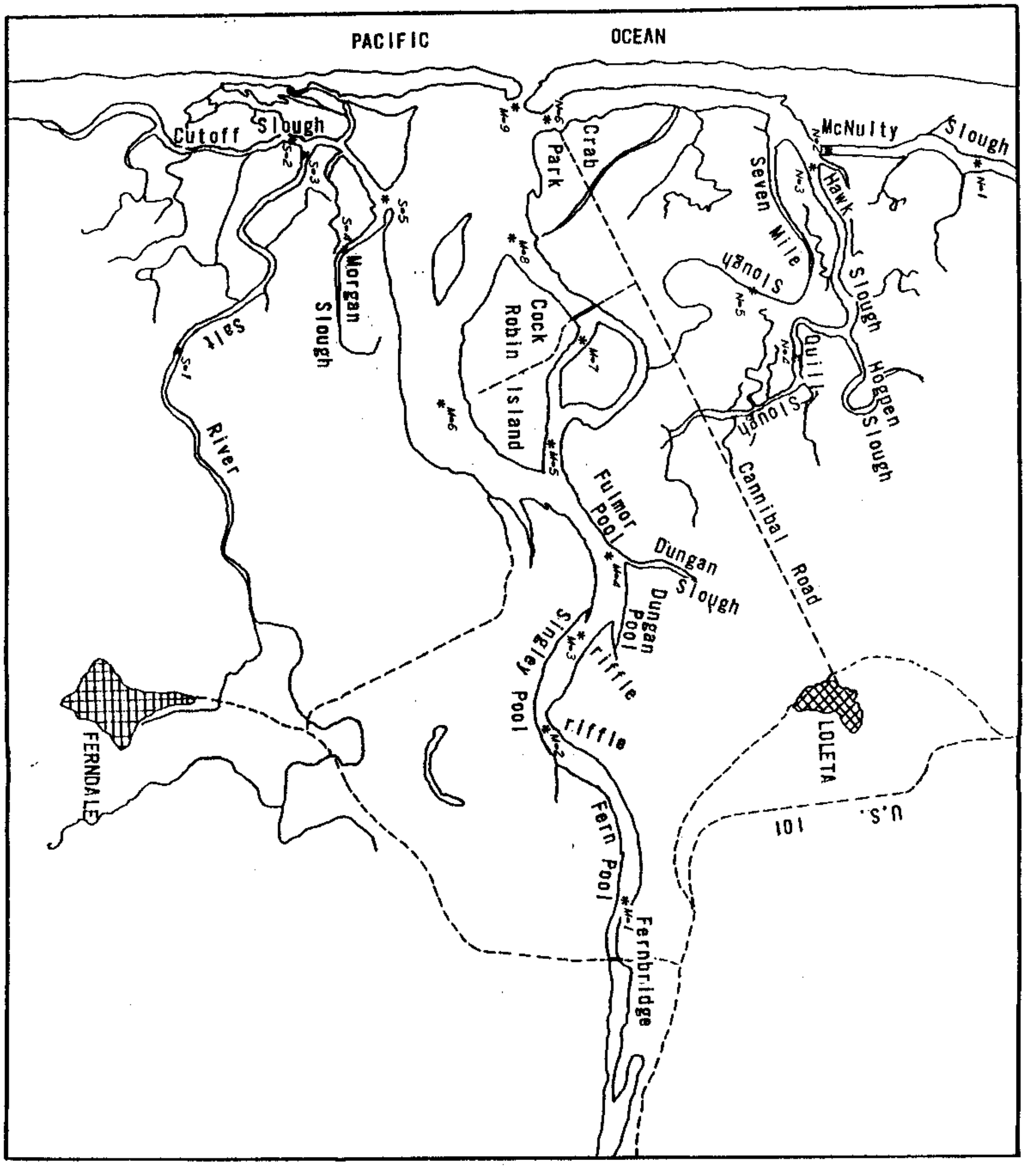
The Eel River enters the Pacific Ocean approximately 322 km (200 miles) north of San Francisco Bay, or 14 km (9 miles) south of the mouth of Humboldt Bay, in Humboldt County, California. Tidal influence extends upstream from the mouth approximately 11 km (7 miles), giving the lower river its estuarine character. The estuary is composed of three main channels: the Eel River, North Bay, and Salt River (Figure 1).

Climatic conditions can best be termed cool mediterranean, with dry summers and very wet winters. Low coastal fog is common during the summer.

The Eel River estuary receives the runoff from approximately 9,324 km^2 (3,600 $miles^2$) of coast range watershed. The mean annual runoff is about 0.8 million hectare meters (6.3 million acre-feet), approximately 90 percent of which occurs between the months of October and May. Flooding of delta land is not an uncommon event, with major floods occurring in 16 of the past 120 years.

FIGURE 1

Eel River Estuary and Sampling Stations



PACIFIC
OCEAN
Cutoff Slough
Morgan Slough
Salt River
Crab Park
Cock Robin Island
Seven Mile Slough
McNulty Slough
Hawk Slough
Hogpen Slough
Quill Slough
Cannibal Road
Fulmor Pool
Dungan Slough
Dungan Pool
Singley Pool
riffle
riffle
Fern Pool
Fernbridge
FERNDALE
LOLETA
U.S. 101

METHODS

Stations were selected for water sampling in the North Bay and Salt River, their contributing sloughs, and the main channel (Figure 1). Sampling was done at both low and high tides. Tide times were obtained from National Ocean Survey (1974 and 1975) for Humboldt Bay. The tide schedule for the Eel River estuary was adjusted using the figures for tide lag from NOS (1975).

Estuary morphology was obtained from photographs taken from NASA U-2 flights on January 4, 1977, between the times of 1945 and 2013.

Eel River flow at Fernbridge was estimated by adding USGS data for the Van Duzen River at Bridgeville, the Eel River at Scotia, and an estimate of the amount of flow from the drainage basin not measured. This estimate was obtained by calculating the drainage area not covered by the gages at Bridgeville and Scotia, and assuming the same ratio of flow/drainage area as the Van Duzen River.

Water column temperature and electrical conductivity (EC) were measured with a Beckman RB3 Solu Bridge, calibrated at the water surface with a Taylor hand-held mercury filled thermometer.

Dissolved oxygen (DO) was measured using the azide modification of the Winkler method (APHA 1975). Samples for analysis were obtained with a Van Dorn water bottle.

The pH was measured in the field with a Hellige Pocket Comparator, Model 605.

Turbidity was measured with a Hach Model 2100A turbidimeter at the Department of Water Resources, Northern District, laboratory.

Soil analysis of bottom material was performed at the Northern District laboratory in 1975. Samples were oven dried at 100°C., weighed, soaked in hydrogen peroxide for 24 hours, and washed over a No. 200 U. S. Standard Sieve. Samples were again oven dried, and allowed to cool. They were then shaken over a series of sieves for 15 minutes, and the material retained by each sieve was weighed. An estimation of the composition of additional samples was made in the field during 1976 using the criteria of the United Soil Classification System (USBR 1963).

Samples for total organic carbon (TOC), nutrients, and mineral analyses were collected from the surface and treated according to APHA (1975). Analyses were performed by the Department of Water Resources laboratory at Bryte.

Aquatic invertebrates were collected during the summers of 1975 and 1976 by the use of hands, dip nets, bottom trawls, and hoop nets baited with dead fish. Organisms caught were fixed in 10 percent formalin, except for crabs. A few crab specimens of each species were preserved in formalin for laboratory identification, but all others were measured across the body directly in front of the lateral spines, and released. All preserved organisms were transferred to 70 percent ethanol. Identification was made using keys by Smith et al (1967), Miller and Lea (1972), and Smith and Carlton (1975), and descriptive guides by Guberlet (1962), and Ricketts and Calvin (1966).

Aufwuchs were used to establish periphyton assemblages. Aufwuchs were placed at the mouth of McNulty, Hawk, and Cutoff Sloughs, and Salt River. After ten days, the aufwuchs were scraped clean and all material placed in jars with 10 percent formalin. Identification was made at the Bryte laboratory.

RESULTS AND DISCUSSION

Estuary Morphology

Morphological changes in the Eel River estuary are the result of two forces, the freshwater flows from the Eel River and ocean waters surging with the tide. The configuration of the estuary has changed considerably during the last hundred years. Upstream activity has resulted in the estuary becoming increasingly filled by sediment. Haley (1970) has reviewed the changes occurring in the estuary between 1950 and 1969. Puckett (1977) describes further changes up to 1974. The present configuration is the result of this sedimentation, several large floods (1956, 1964, and 1974), tidal action, and the present drought.

Puckett (1977) shows the estuary as it was in 1974, with two main channels, one to the south and the other to the north of Cock Robin Island, with a small slough running through the island. In 1976, the channel to the north of Cock Robin Island was too shallow at low tide to float a car-top boat. The main channel of the estuary was through the widened slough running through Cock Robin Island. It was difficult to find the channel on the south side of the island, and in many places it was necessary to drag the boat over shallow sand bars. In April, 1977, passage through the former channel to the north of Cock Robin Island was blocked at both low and high tides, and the main river flow had shifted to the channel south of the island. In addition, the lower portion of the estuary contained more extensive sand bars that were exposed at low tides, extending from Cock Robin Island to within 100 meters of the mouth. The pools above Cock Robin Island have changed little since 1974.

Streamflow

Eel River flow estimates for the water years 1973-74, 1974-75, 1975-76, and 1976-77, are shown in Figures 2 through 5. Flow estimates for the low flow months are shown on an expanded scale in Figure 6, except for the 1976-77 water year. The highest flows occurred during the 1973-74 water year, with daily maximum flows over 2,830 m^3/s (100,000 cfs) on ten different occasions. On two of these occasions, the daily maximum flows were over 8,490 m^3/s (300,000 cfs), with the maximum flow of 10,980 m^3/s (388,000 cfs) occurring in January 1974. The minimum flow occurred in September, when 3.25 m^3/s (115 cfs) was recorded for the daily average flow. The total runoff past Fernbridge for the 1973-74 water year amounted to approximately 1,786,600 ha-m (14,478,000 AF).

The 1974-75 water year produced peak flows of 5,630 m^3/s (199,000 cfs) and 6,735 m^3/s (238,000 cfs) in February and March, respectively. The minimum flow of 3.62 m^3/s (128 cfs) occurred in September. The total run-off past Fernbridge for the 1974-75 water year amounted to approximately 1,057,300 ha-m (8,568,000 AF).

The 1975-76 water year peak flow of 2,890 m^3/s (102,000 cfs) occurred in February. The minimum flow of 3.71 m^3/s (131 cfs) occurred in September. The total runoff past Fernbridge for the 1975-76 water year amounted to approximately 412,300 ha-m (3,341,000 AF), the lowest outflow since 1947.

The 1976-77 water year, up to June 1, was the dryest year on record. The maximum daily flow that occurred was 88.2 m^3/s (5,582 cfs) in February; the highest average daily flow for any one month also occurred in February (42.2 m^3/s - 1,490 cfs). This water year will undoubtedly contribute the lowest runoff past Fernbridge on record.

Freshwater flows entering the estuary affect the salinity patterns, and thus the area available to halophilic and halophobic organisms. High freshwater flows (25.5 m^3/s - 900 cfs) from the Eel River limit the salt water influence to below Dungan Pool (m-4) at low tide. However, at high tide, salt water is allowed to move up channel beneath the freshwater in Dungan Pool, but is still prevented from ascending into the riffle (m-3) above this pool (Appendix A). The integrity of the freshwater flow over the denser saline water breaks down below Dungan Pool due to mixing of the surface freshwater and deeper salt water, yet a salinity gradient from surface to bottom exists. Dilution of the sea water exists throughout the lower estuary.

Lower freshwater flows (10.5 m^3/s - 370 cfs) from the Eel River permits the intrusion of salt water into Dungan Pool (m-4) even during low tide (Appendix A). At low tide, little mixing of the surface freshwater and deeper salt water occurs, but at high tide mixing is increased. Tidal water is still prevented from ascending the riffle (m-3) above Dungan Pool. Dilution of the salt water by fresh water is less so that full strength sea water may be found below the Cock Robin Island bridge (near m-7).

At still lower flows (6.8 m^3/s - 240 cfs) and a high tide, salt water exerts an influence on the salinity as far as the riffle (m-2) above Singley Pool (Appendix A). The salinity is slightly elevated at low tide at this riffle, but this is probably due to drainage of interstitial saline water from the high tide into the freshwater flow. Fern Pool (m-1), the farthest station inland, maintained its freshwater character regardless of the tide stage. Although full-strength sea water is still found only about as far as the Cock Robin Island bridge, dilution by the fresh water is less so that higher surface salinities are found in all the lower areas of the estuary.

FIGURE 2

Estimated Monthly Maximum and Minimum
Eel River Flow for the 1973-74 Water Year

Maximum

Mean

Minimum

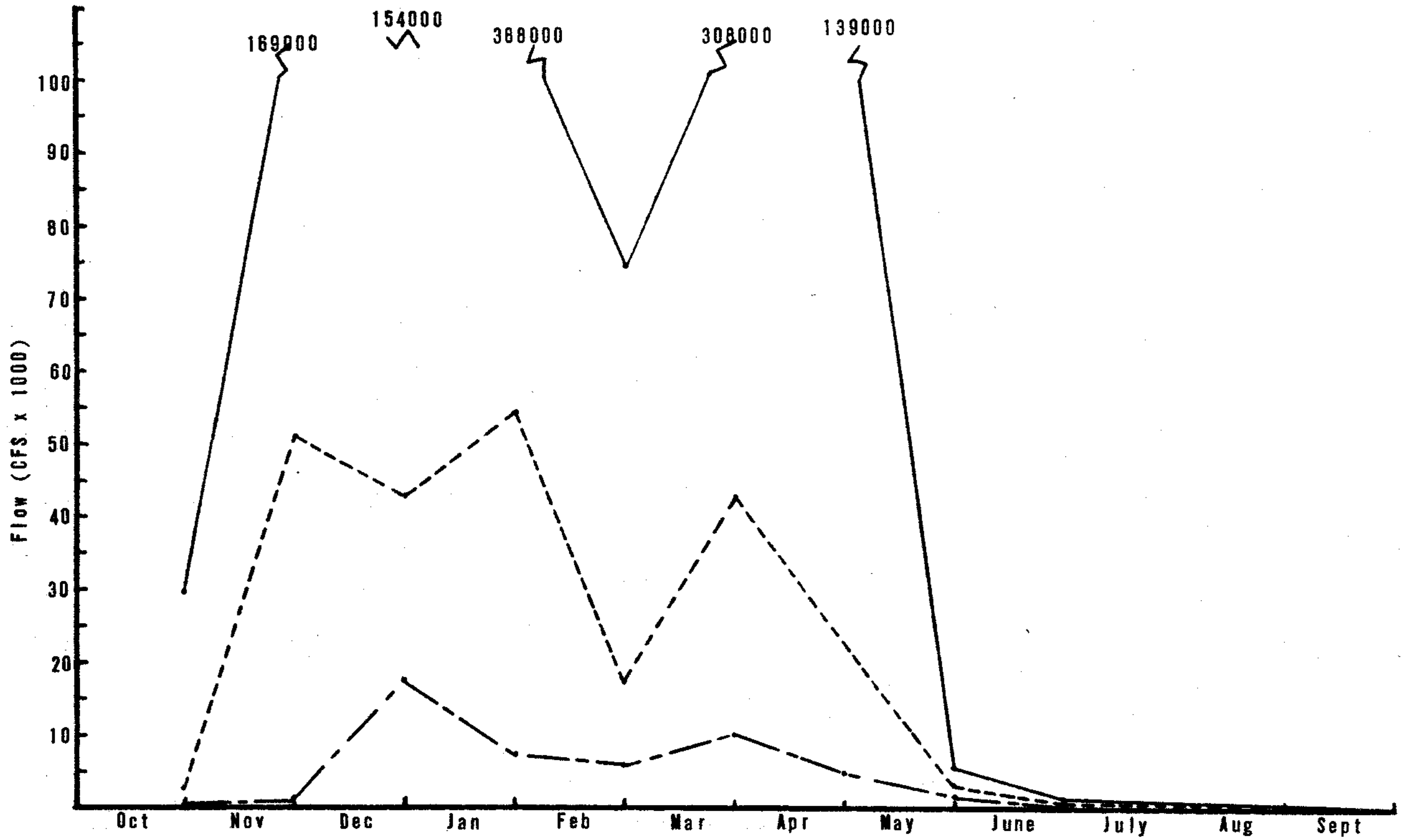

Flow (CFS x 1000)
100
90
80
70
60
50
40
30
20
10
169000
154000
368000
308000
139000
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept

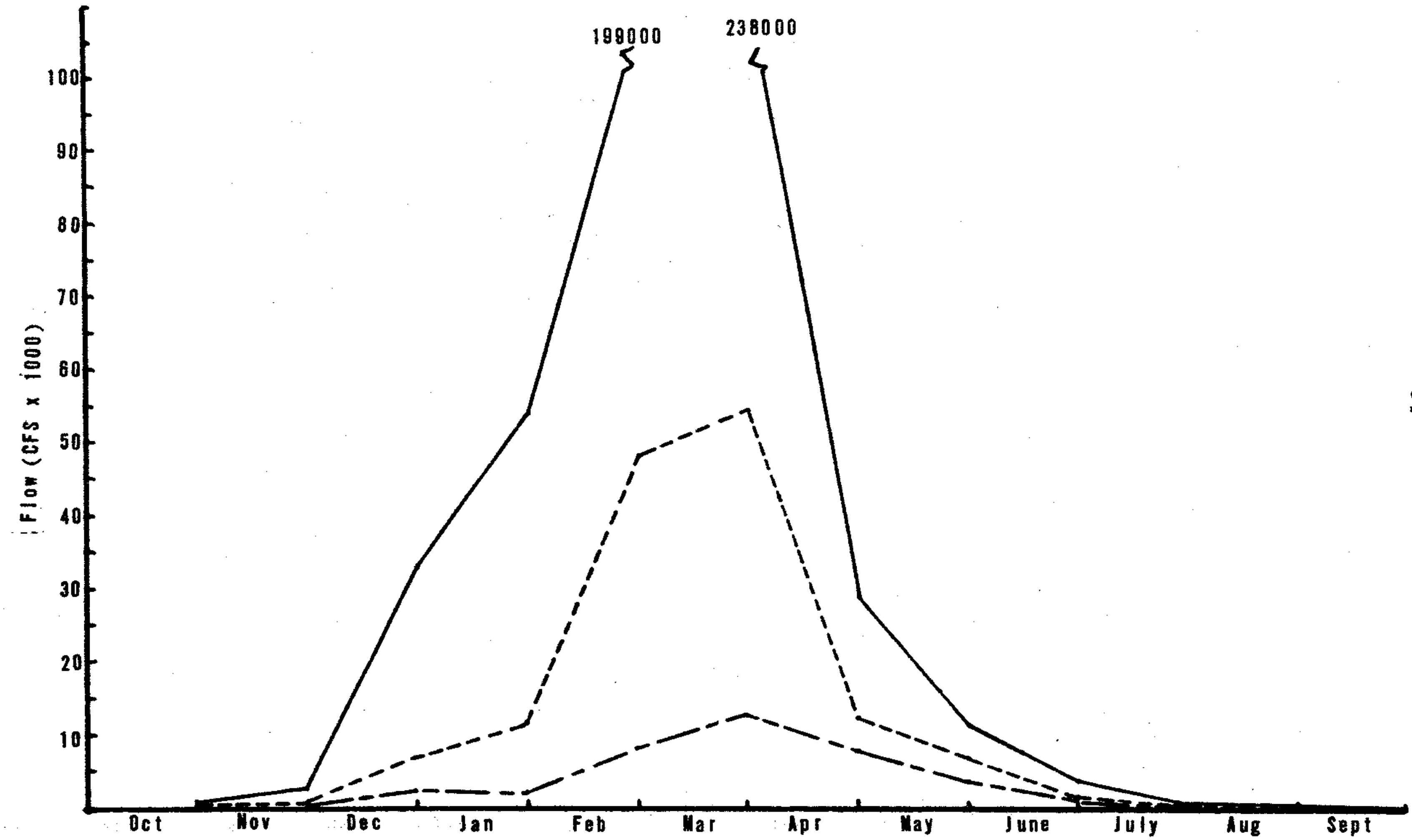
FIGURE 3

Estimated Monthly Maximum and Minimum
Eel River Flow for the 1974-75 Water Year

Maximum

Mean

Minimum



199000
238000
100
90
80
70
60
50
40
30
20
10
Flow (CFS x 1000)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept

FIGURE 4.

Estimated Monthly Maximum and Minimum
Eel River Flow for the 1975-76 Water Year

————	Maximum
- - - - - -	Mean
— - — - —	Minimum

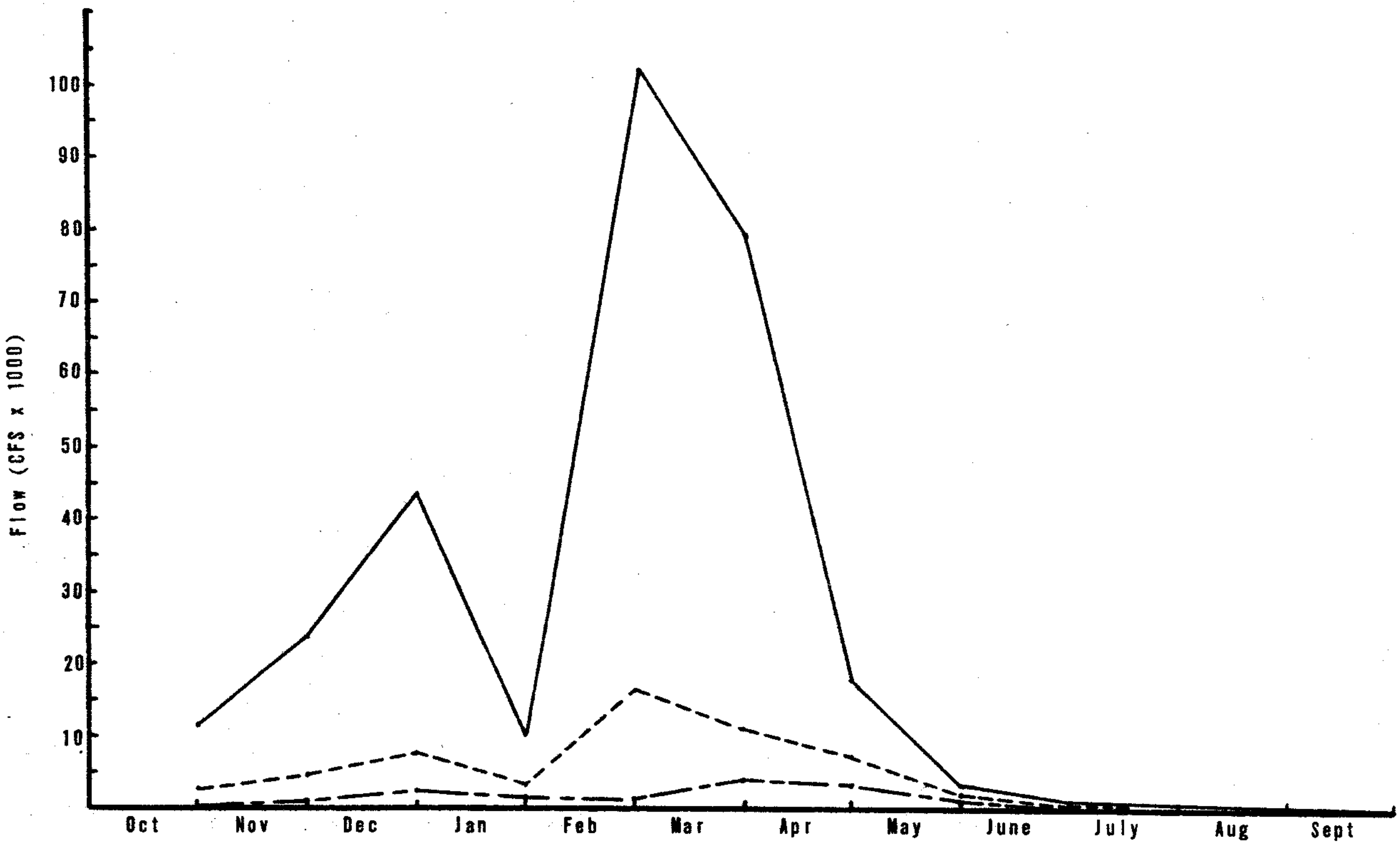

Flow (CFS x 1000)
100
90
80
70
60
50
40
30
20
10
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept

FIGURE 5

Estimated Monthly Maximum and Minimum
Eel River Flow for the 1976-77 Water Year Through May

Maximum
Mean
Minimum

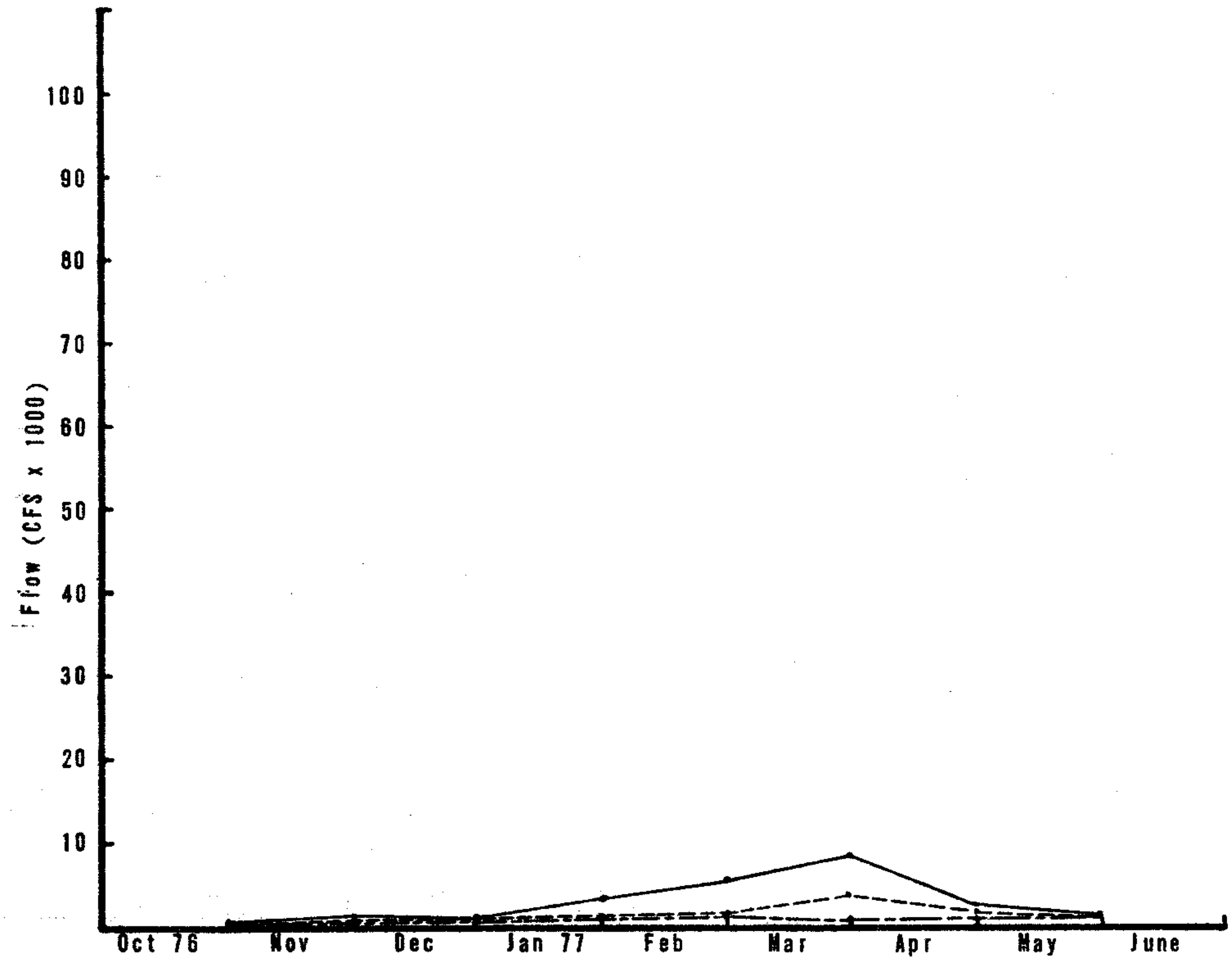
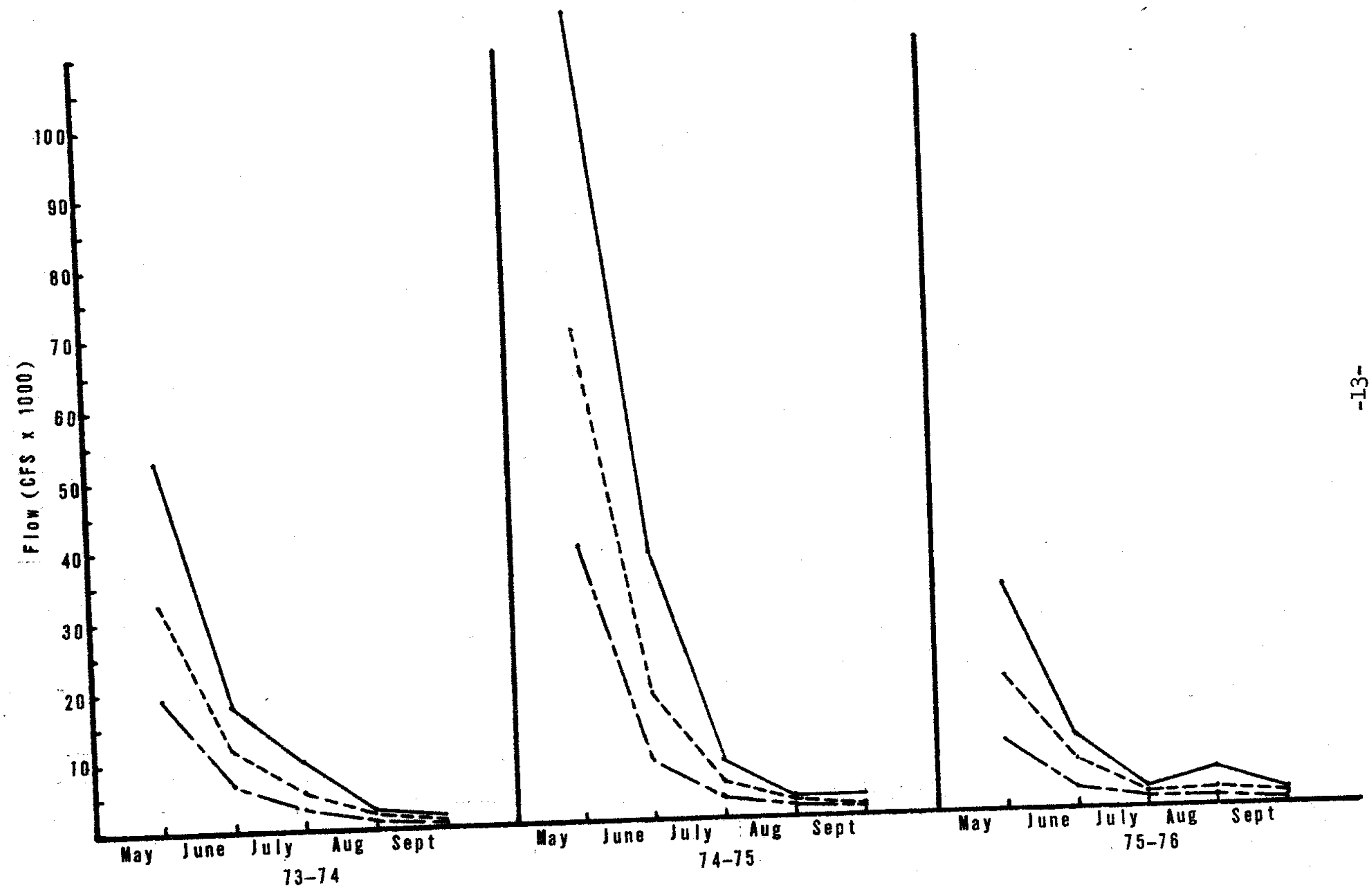

Flow (CFS x 1000)
100
90
80
70
60
50
40
30
20
10
Oct 76
Nov
Dec
Jan 77
Feb
Mar
Apr
May
June

FIGURE 6

Estimated Eel River Flows for Low Flow Months
1973-74, 1974-75, and 1975-76 Water Years

———	Maximum
- - - - -	Mean
—-—-—	Minimum


Flow (CFS x 1000)
100
90
80
70
60
50
40
30
20
10
May
June
July
Aug
Sept
73-74
May
June
July
Aug
Sept
74-75
May
June
July
Aug
Sept
75-76

Electrical Conductivity

Electrical conductivity in the Eel River estuary is highly variable with sampling location, tidal stage, and surface runoff. Conductivity relationships between high and low tides for various times and locations are shown in Figures 7 through 25.

These figures indicate that an inverse relationship exists between the amount of surface runoff and EC. They also indicate that, generally, the EC value for high tide is higher than that for low tide.

The EC-tidal stage relationship at upper McNulty Slough (n-1) (Figure 7), is contrary to the general pattern during the months of low surface flow. The EC is higher at low tide than at high tide. Little tidal mixing occurs between the salt water moving up and freshwater moving down. As the salt water wedge moves up the estuary during high tide, the less dense water of the slough is forced to flow over the denser water of the wedge. Even though the tidal stage is high, a surface measurement of EC at this time would record the less dense surface water. As the tide moves out, the less dense surface water moves first, leaving the denser water of the salt water wedge. A measurement at this low tide period records the EC of the denser water of the salt water wedge. Between low and high tide, the denser water may become diluted from surface runoff or bank storage of less dense water. The cycle is then repeated.

This same pattern appears at Quill (n-4) (Figure 8), and Seven Mile Sloughs (n-5) (Figure 9), during the early summer months. But in late summer, the pattern changes, and EC is higher at high tide than at low tide. Freshwater flow at this time is so slight that little mixing occurs. The water present in the channels is merely moved back and forth with changes in the tide. At high tide, the more saline water from a lower reach is forced up the channel by the tidal water moving up the channel. At low tide, the channel water is allowed to move down channel, so that less dense water moves into a lower position in the channel.

At all other stations of the estuary, except the main channel, the pattern of water movement appears to be the same as at Quill and Seven Mile Sloughs during late summer, although the EC differences between high and low tides is greater (Figures 10 through 16). All these other stations are under greater tidal influence. The salt water wedge is less diluted, and moves a greater distance up the sloughs. At these stations, because of the greater movement, exchange does occur between the water of the sloughs and the ocean.

The tidal effects in the main channel extend nearly to Fernbridge. At m-1 (Figure 17), there is no mixing of saline with freshwater, but there is a change in water depth with tide stage. As the tide moves in, the water is prevented from flowing as rapidly and becomes ponded. When the tide moves out, the water is again allowed to flow and returns to a riffle state. The EC at this station is the same as that for the Eel River above Fernbridge, about 250.

At m-2 (Figure 18), several factors act to affect the EC. During the early part of summer, flows are substantial enough across the riffle to prevent the intrusion of the salt water wedge. But, as the flow become decreased during late summer, salt water is allowed to move upstream during high tide. At low tide, even though there is no longer mixing of freshwater with salt water of the wedge, an elevated EC is maintained due to seepage of interstitially stored salt water into the freshwater.

This same pattern exists at the riffle at m-3, except the influence of salt water is greater. The water becomes ponded to a greater depth at high tide, and a definite EC stratification exists between the surface and the bottom (Figure 19). This stratification is removed at low tide, but interstitially stored salt water maintains a slightly elevated EC.

Station m-4 represents a pool environment. Stratification exists at both low and high tides. As the river flow decreases during the summer, the EC at each strata increases, with the surface showing the greatest increase, at both low and high tides (Figure 20). Surface EC was always higher at high tide than low tide, the result of increased mixing with salt water, and decreased dilution, due to the ponding upstream of the freshwater flow.

A similar pattern occurs at all other stations in the main channel. As the stations become closer to the mouth of the estuary, the influence of freshwater flow from the Eel River becomes less, while that of ocean water increases (Figures 21 through 25). EC is greater at all depths as stations become closer to the mouth, and approaches that of full sea water at the mouth.

FIGURE 7

Electrical Conductivity
at Upper McNulty Slough (N-1)

——————— High Tide

- - - - - - - - - - - Low Tide

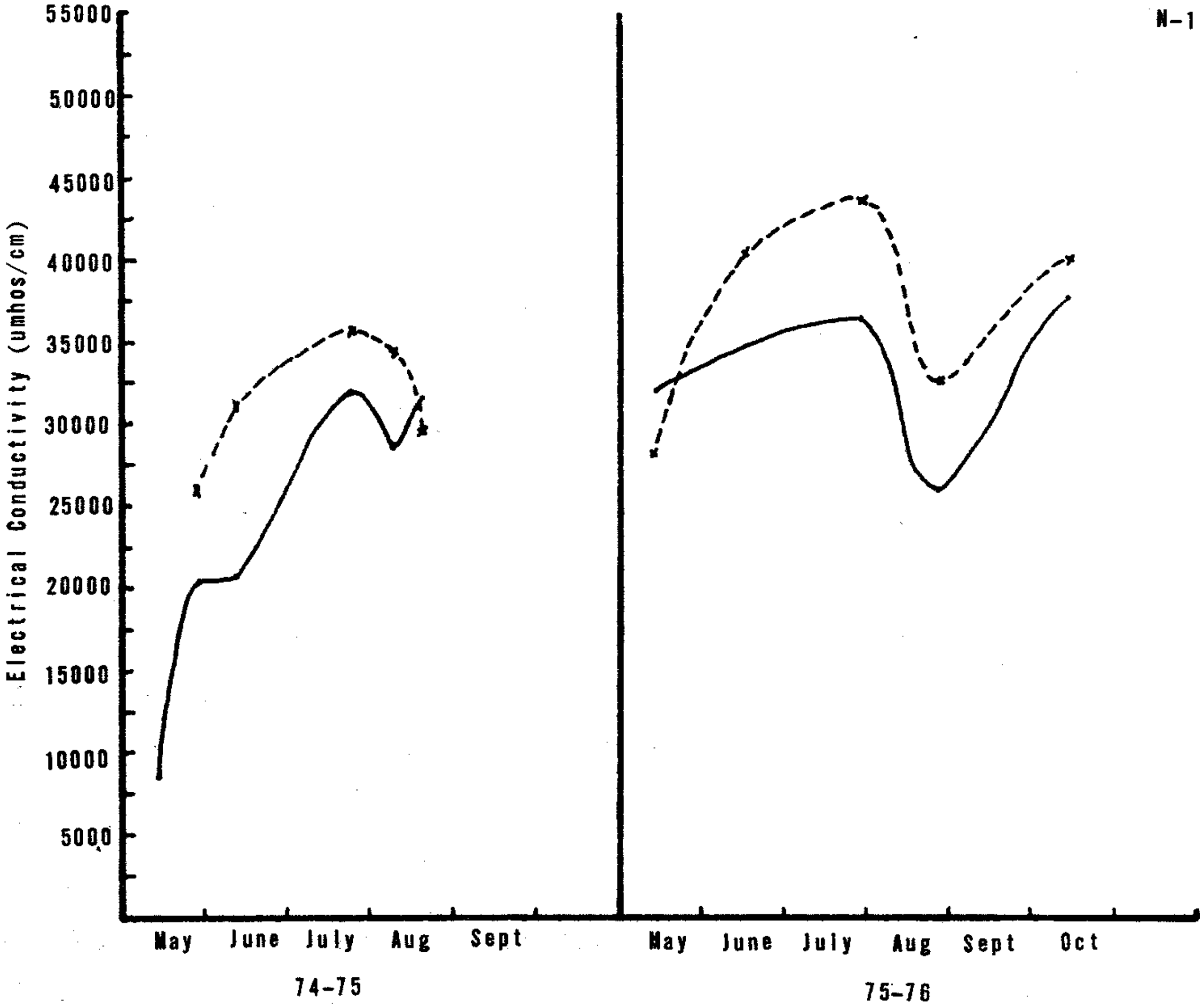

N-1
Electrical Conductivity (umhos/cm)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
May
June
July
Aug
Sept
74-75
May
June
July
Aug
Sept
Oct
75-76

FIGURE 8

Electrical Conductivity
at Quill Slough (N-4)

———————— High Tide
------------- Low Tide

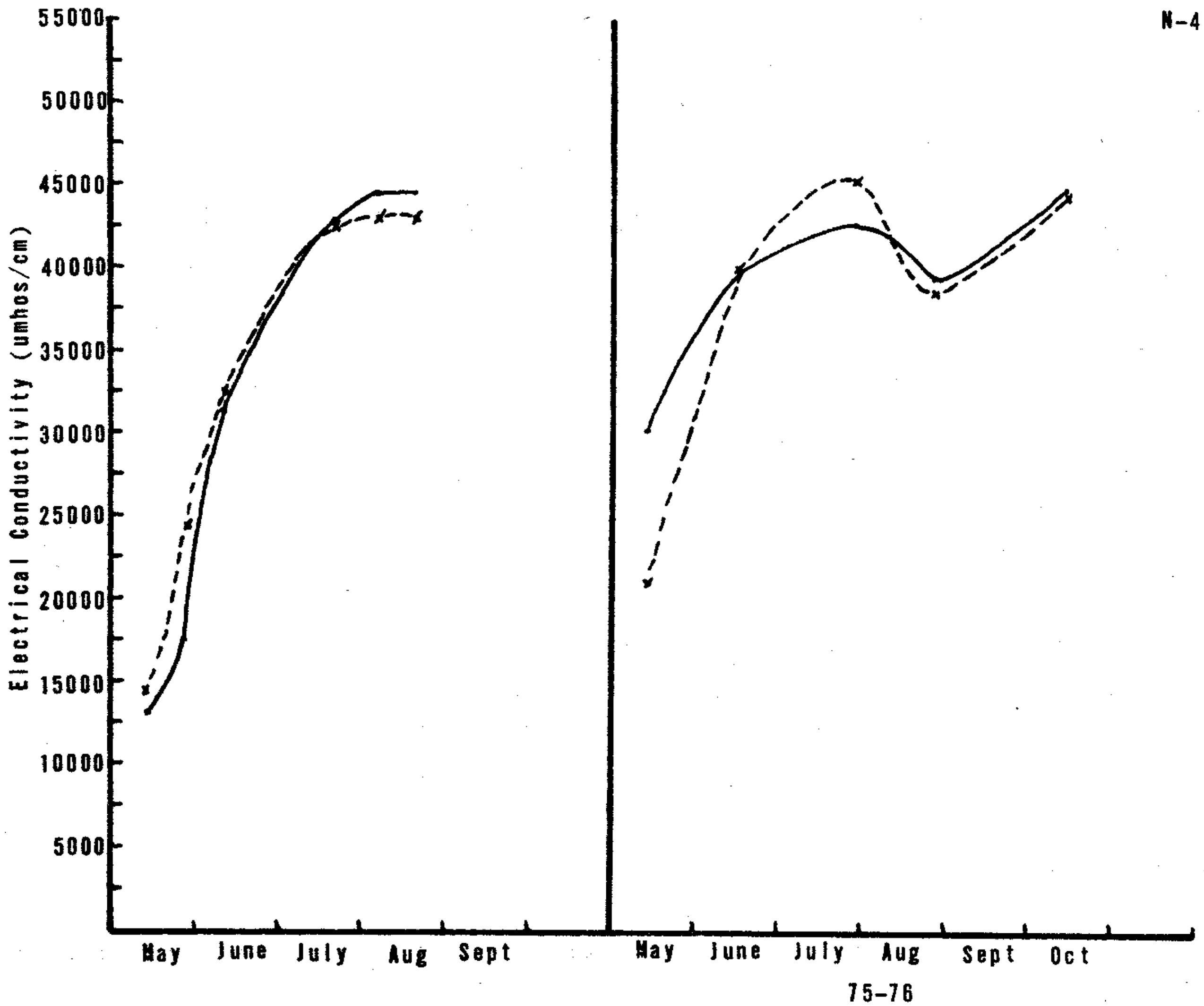

N-4
Electrical Conductivity (umhos/cm)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
May
June
July
Aug
Sept
May
June
July
Aug
Sept
Oct
75-76

FIGURE 9.

Electrical Conductivity
at Seven Mile Slough (N-5)

——————— High Tide

----------- Low Tide

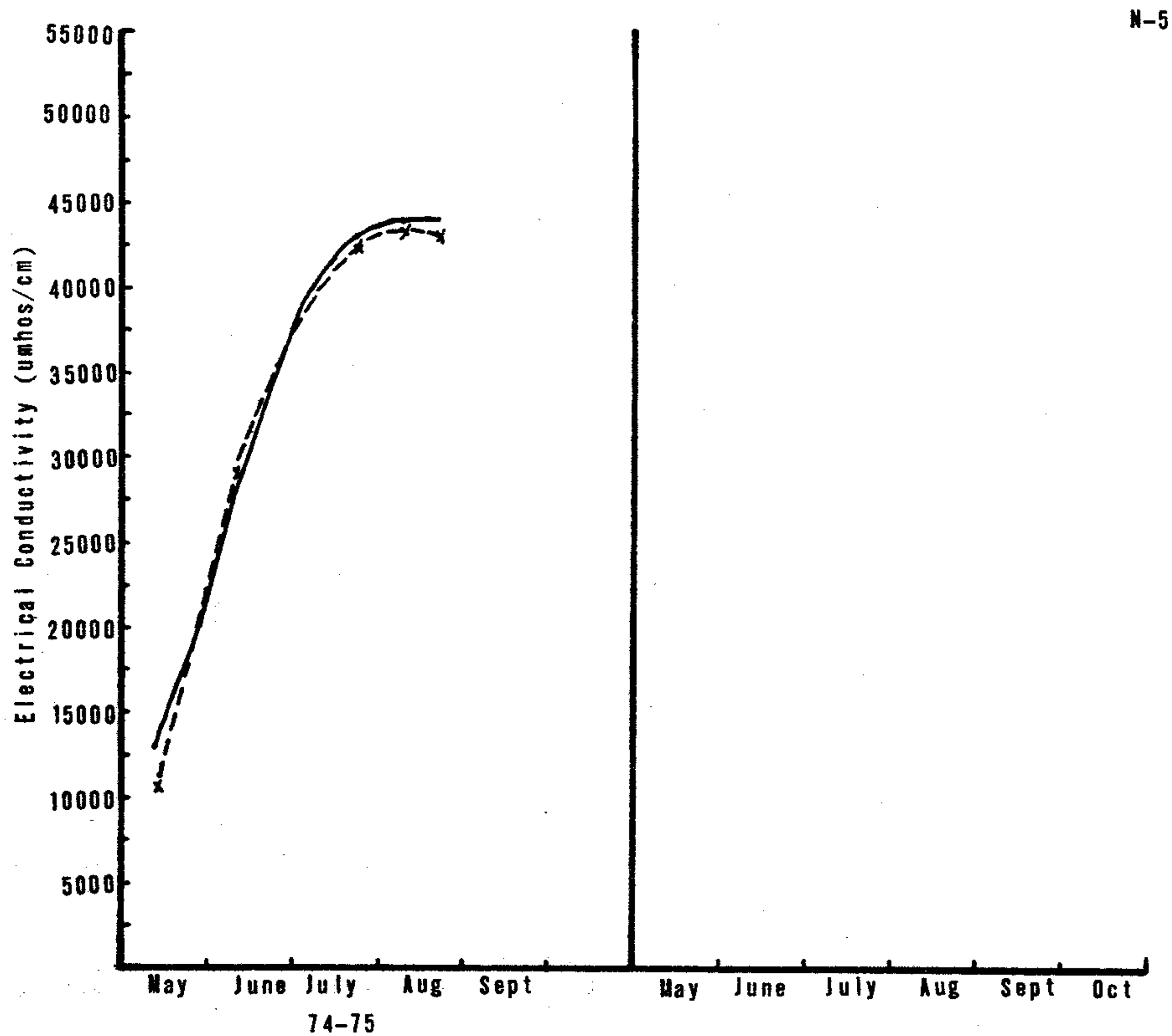
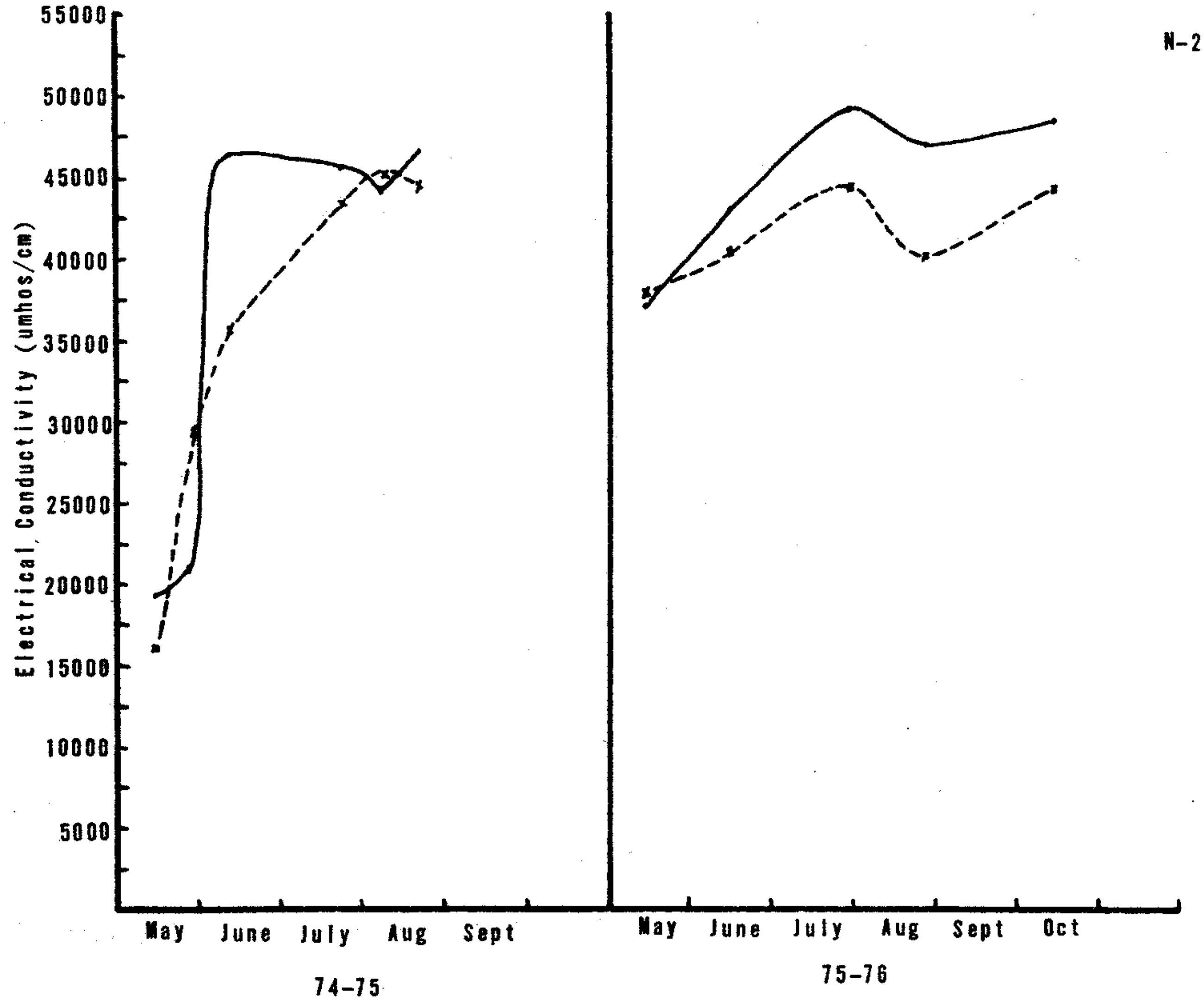

N-5
Electrical Conductivity (umhos/cm)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
May June July Aug Sept
74-75
May June July Aug Sept Oct

FIGURE 10

Electrical Conductivity
at McNulty Slough (at Mouth)
(N-2)

——————— High Tide
------------ Low Tide



N-2
Electrical Conductivity (umhos/cm)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
May
June
July
Aug
Sept
74-75
May
June
July
Aug
Sept
Oct
75-76

FIGURE 11

Electrical Conductivity
At Hawk Slough (at Mouth)
(N-3)

——————— High Tide
- - - - - - - - - - - Low Tide

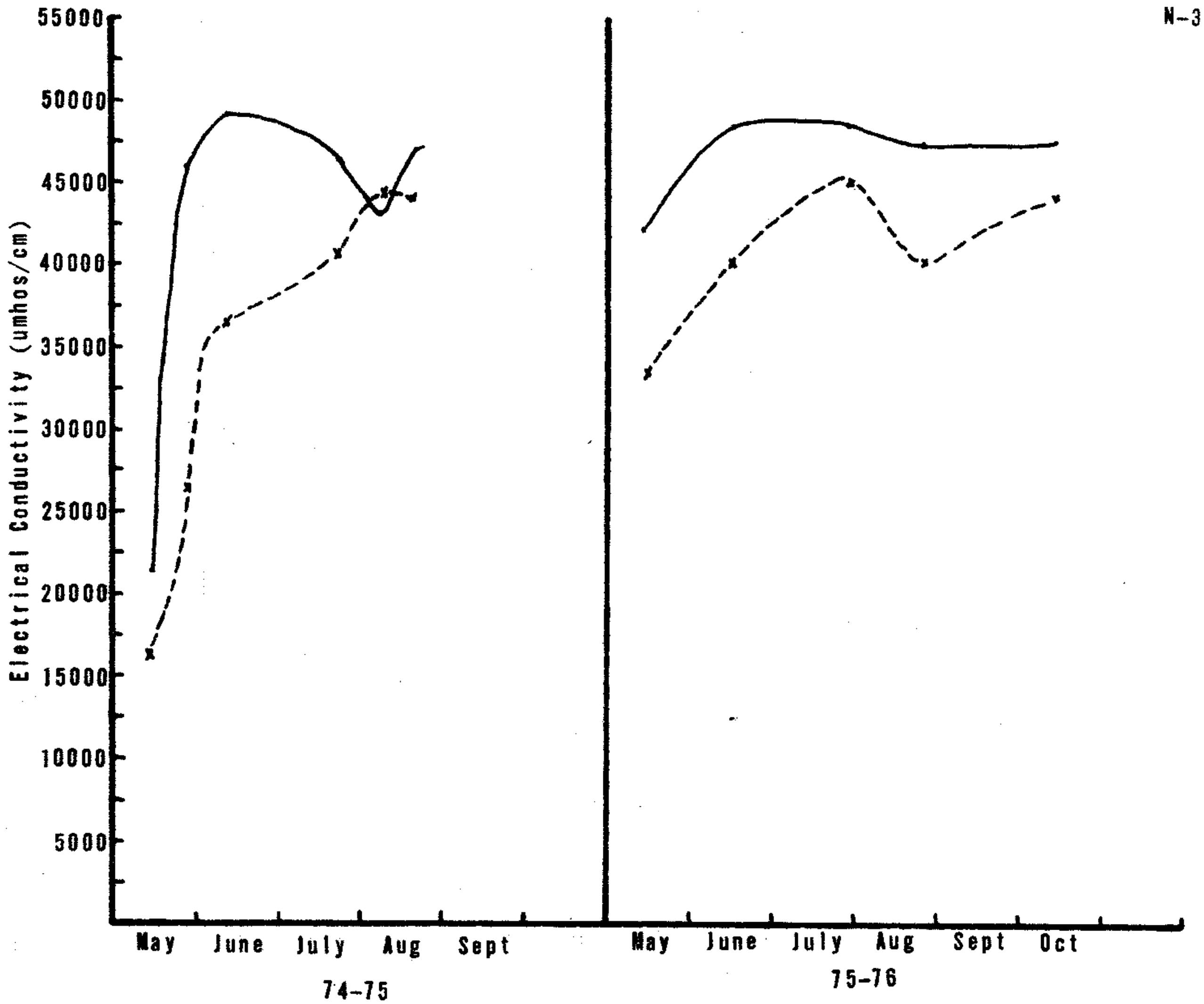

N-3
Electrical Conductivity (umhos/cm)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
May
June
July
Aug
Sept
74-75
May
June
July
Aug
Sept
Oct
75-76

FIGURE 12

Electrical Conductivity
at Crab Park
(N-6)

——————— High Tide
- - - - - - - - - - Low Tide

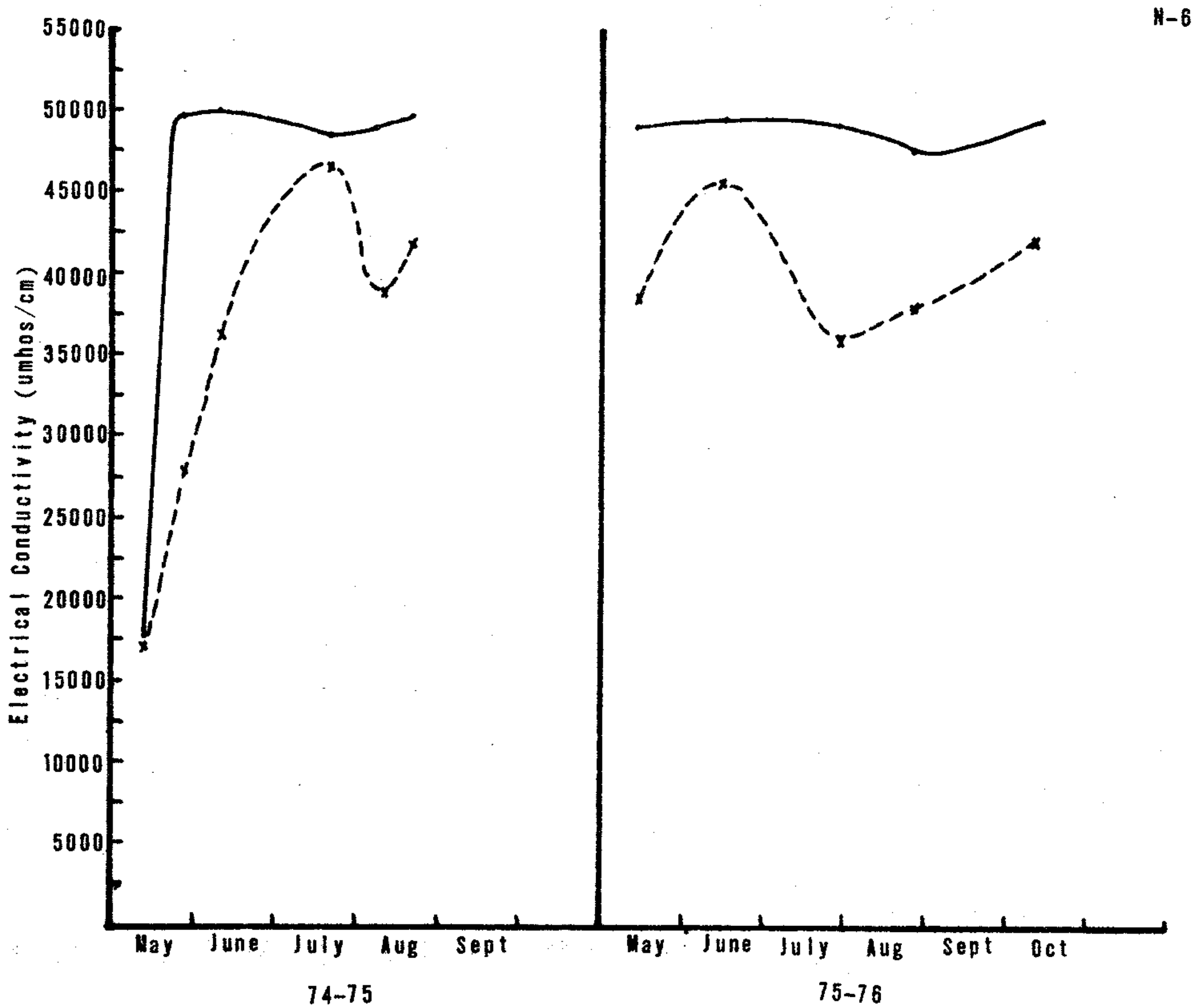

N-6
Electrical Conductivity (umhos/cm)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
May
June
July
Aug
Sept
74-75
May
June
July
Aug
Sept
Oct
75-76

FIGURE 13

Electrical Conductivity
at Upper Salt River
(S-1)

———————— High Tide

------------ Low Tide

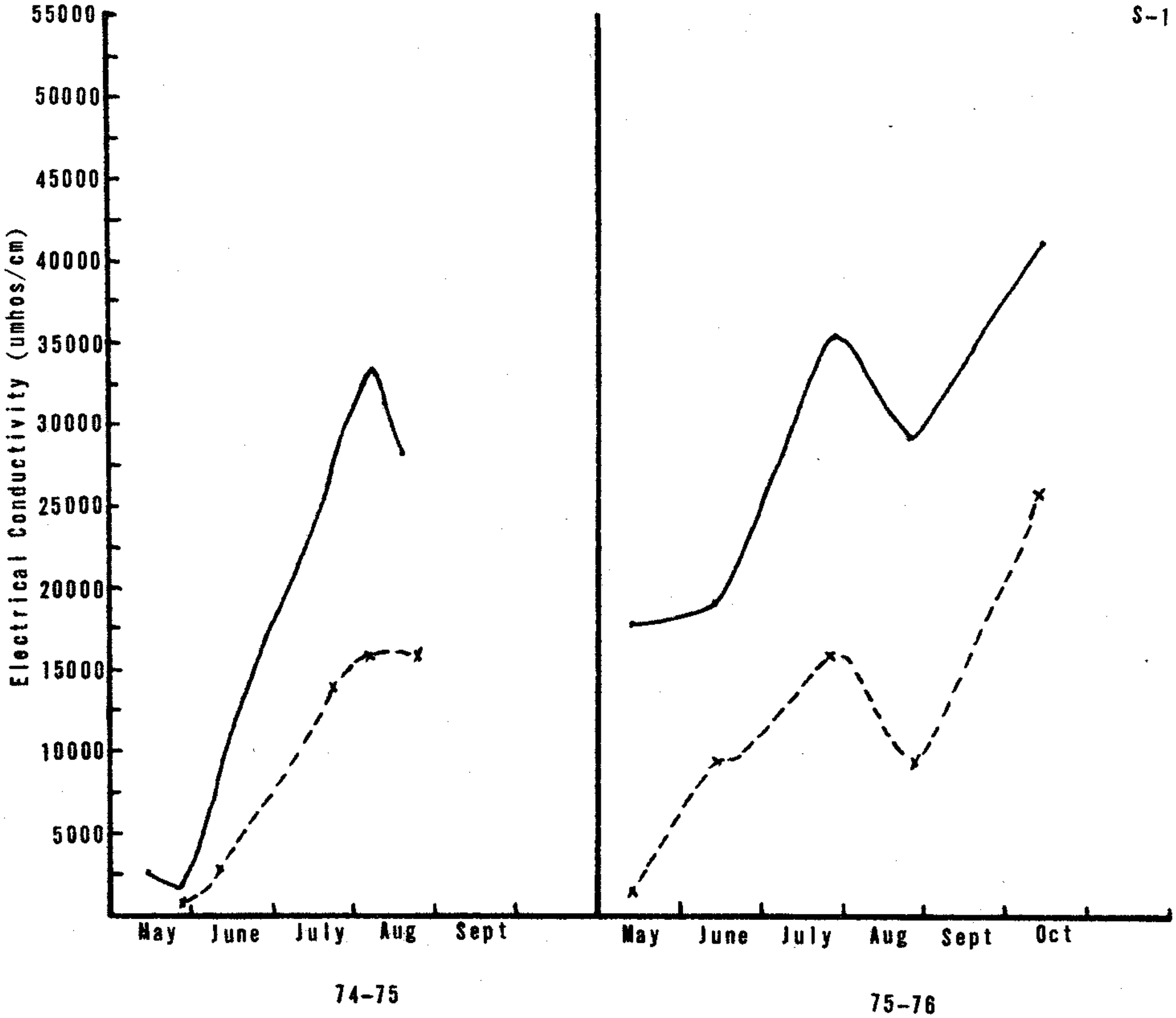

S-1
Electrical Conductivity (umhos/cm)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
May
June
July
Aug
Sept
74-75
May
June
July
Aug
Sept
Oct
75-76

FIGURE 14

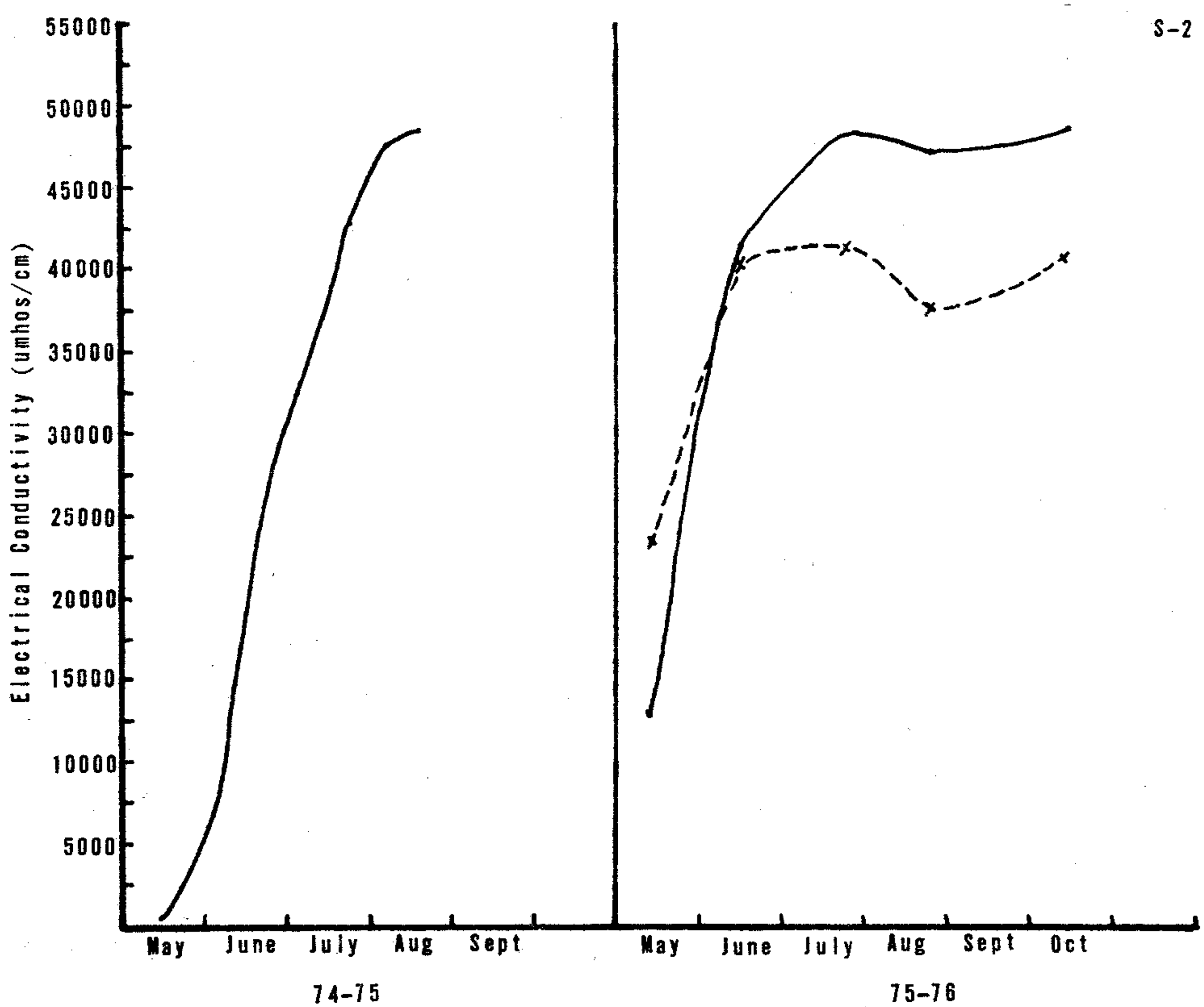
Electrical Conductivity

at Cutoff Slough

(S-2)

———————— High Tide

- - - - - - - - - - - Low Tide



S-2
Electrical Conductivity (umhos/cm)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
May
June
July
Aug
Sept
74-75
May
June
July
Aug
Sept
Oct
75-76

FIGURE 15

Electrical Conductivity
at Salt River (above Cutoff Slough)
(S-3)

——————— High Tide
- - - - - - - - - - - - Low Tide

S-3

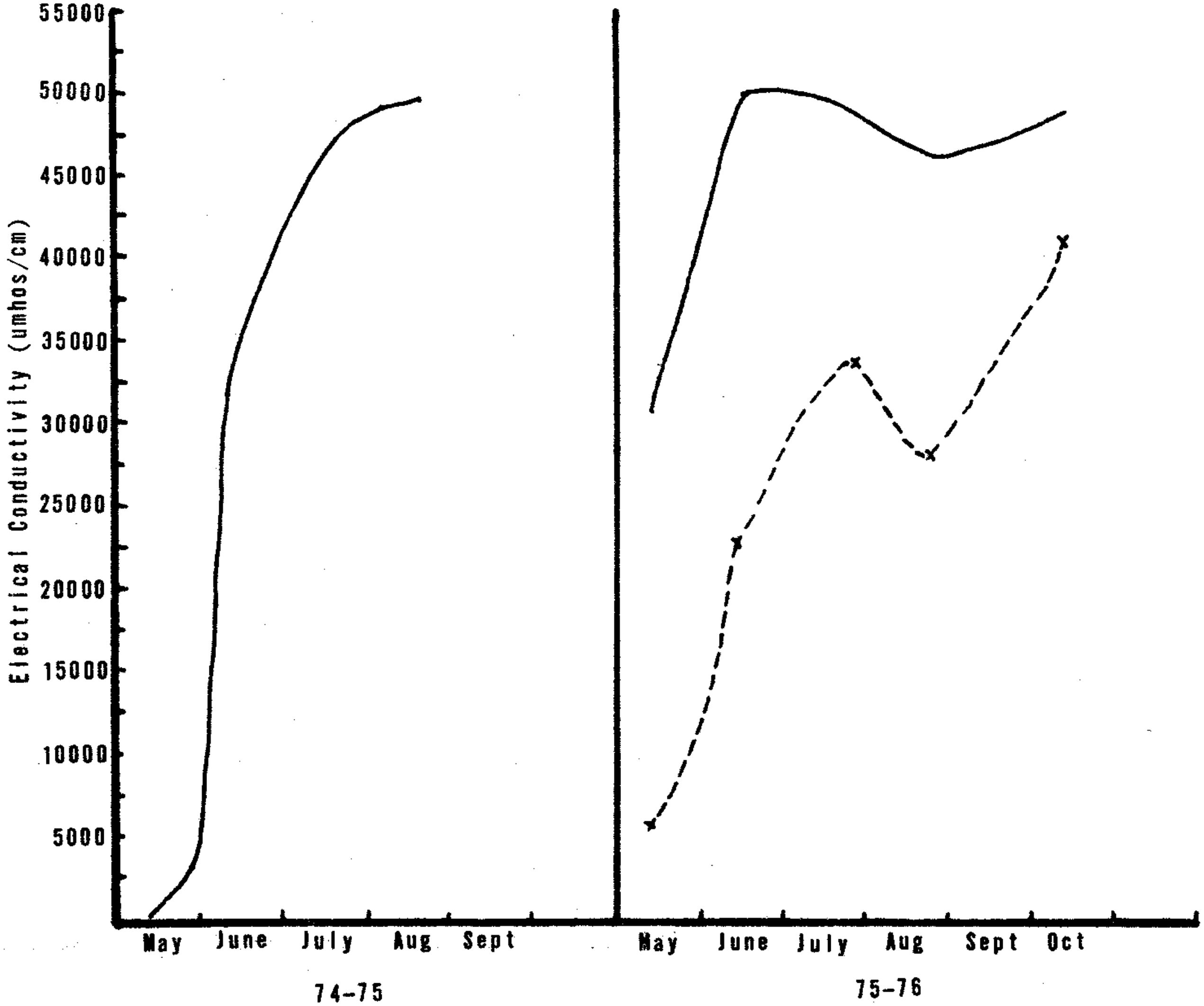

55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
Electrical Conductivity (umhos/cm)
May
June
July
Aug
Sept
74-75
May
June
July
Aug
Sept
Oct
75-76

FIGURE 16

Electrical Conductivity
at Morgan Slough
(S-4)

——————— High Tide
----------- Low Tide

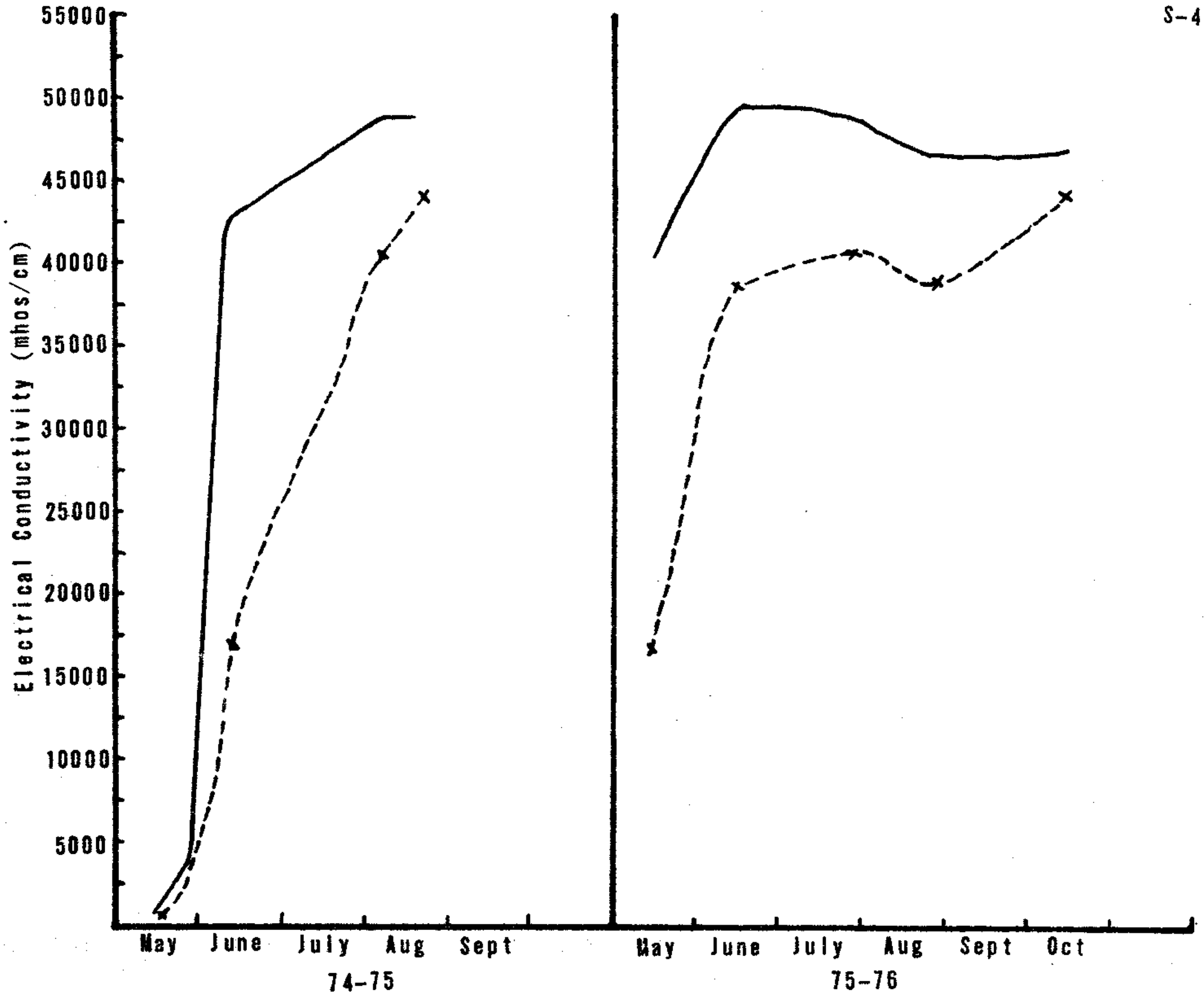

S-4
Electrical Conductivity (mhos/cm)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
May
June
July
Aug
Sept
74-75
May
June
July
Aug
Sept
Oct
75-76

FIGURE 17

Electrical Conductivity
at Fern Pool
(M-1)

——————— High Tide
- - - - - - - - - - - Low Tide

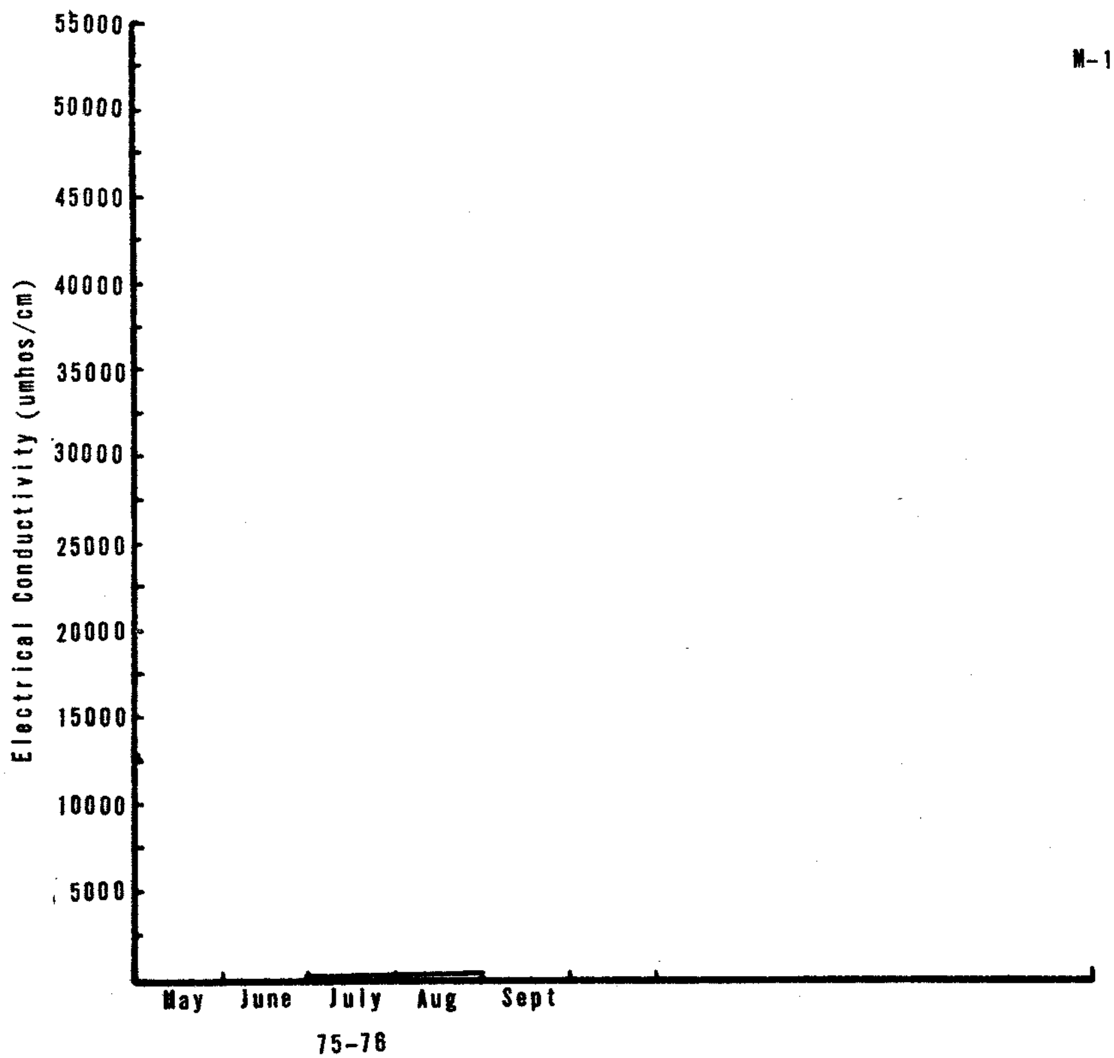

M-1
Electrical Conductivity (umhos/cm)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
May
June
July
Aug
Sept
75-76

FIGURE 18

Electrical Conductivity
above Singley Pool at Riffle
(M-2)

——————— High Tide

----------- Low Tide

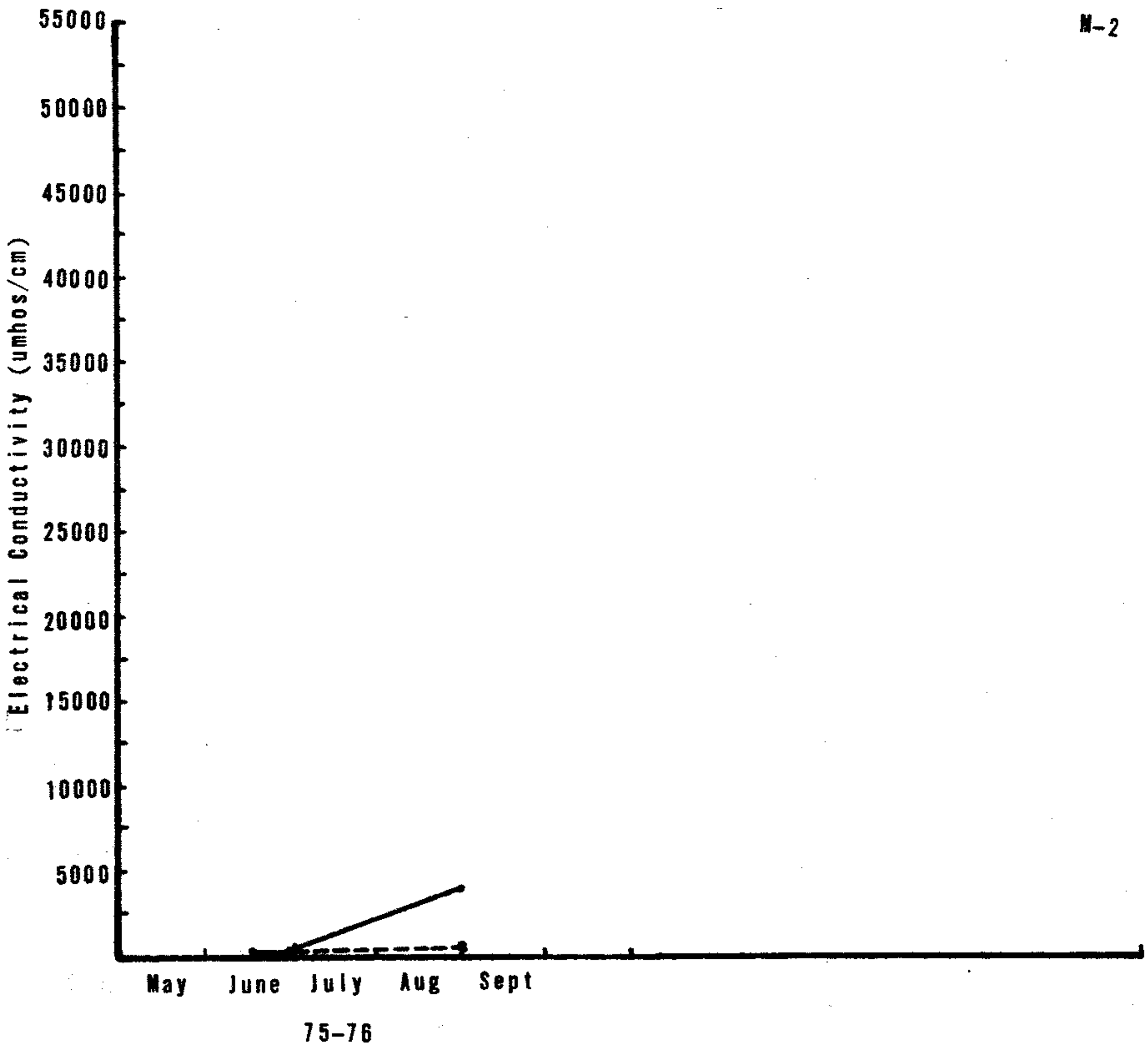

N-2
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
Electrical Conductivity (umhos/cm)
May
June
July
Aug
Sept
75-76

FIGURE 19

Electrical Conductivity
above Dungan Pool at Riffle
(M-3)

———————— High Tide
------------ Low Tide

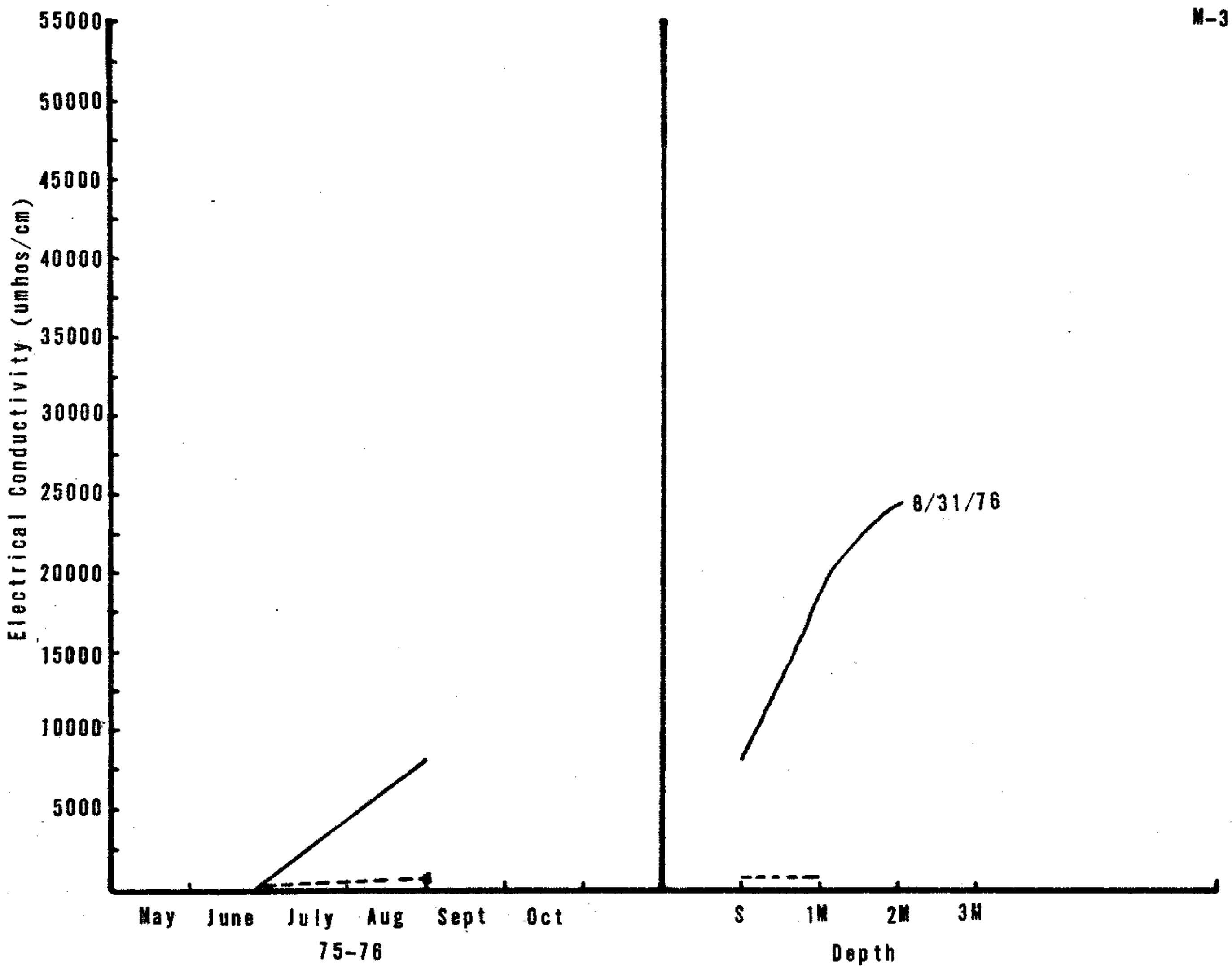

M-3
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
Electrical Conductivity (umhos/cm)
May
June
July
Aug
Sept
Oct
75-76
8/31/76
S
1M
2M
3M
Depth

FIGURE 20

Electrical Conductivity
at Dungan Pool
(M-4)

———————— High Tide
------------ Low Tide

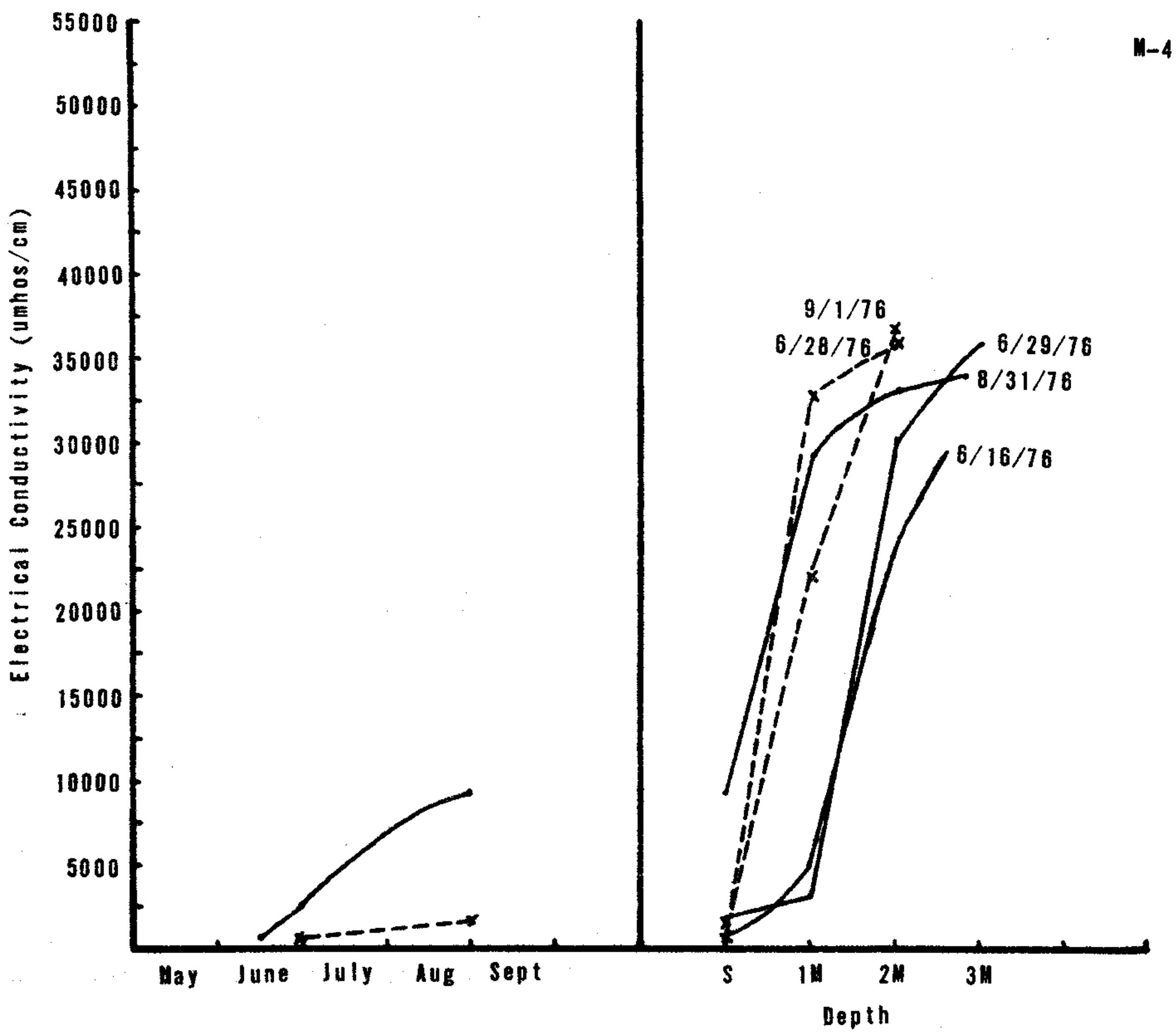
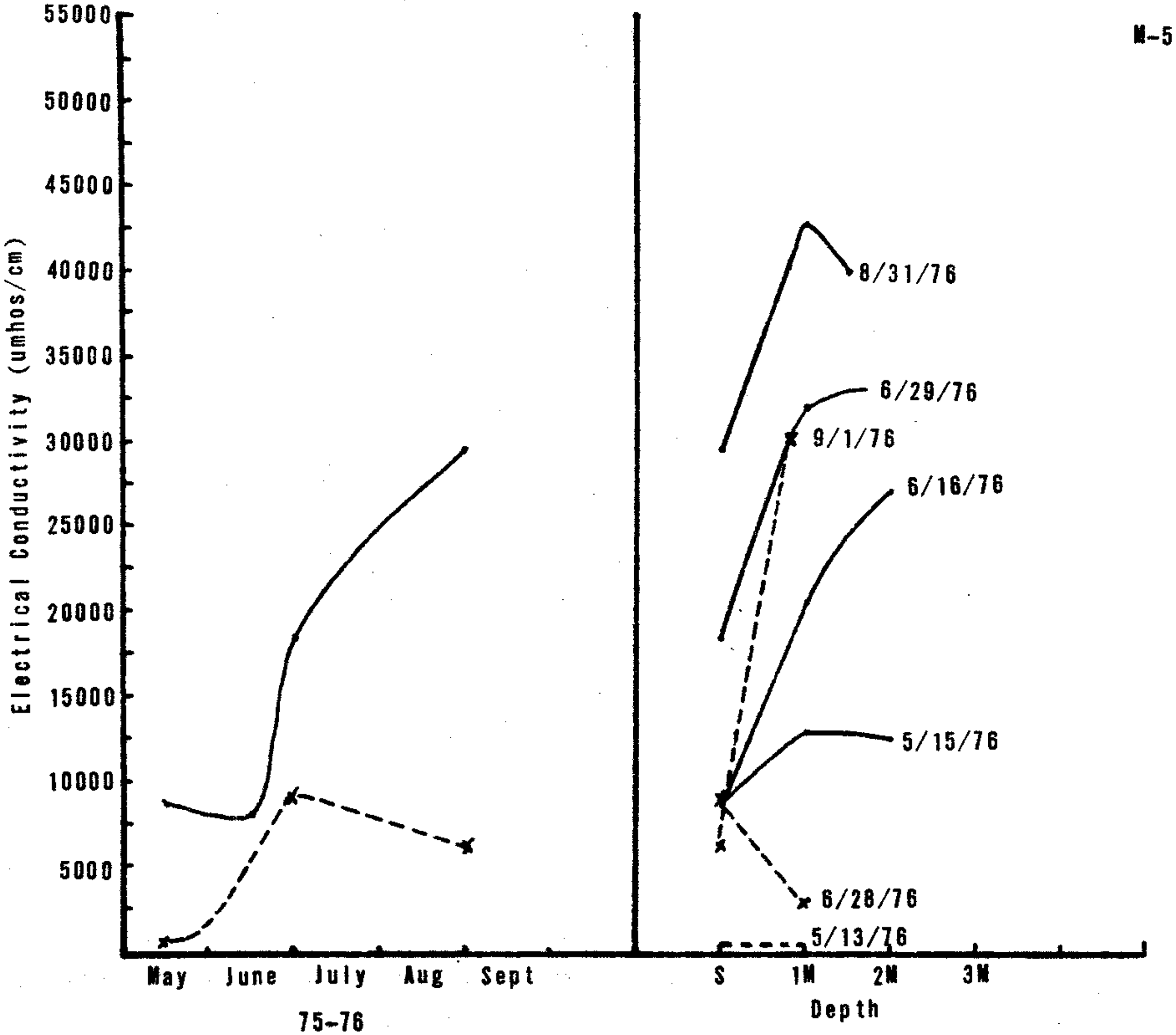

M-4
Electrical Conductivity (umhos/cm)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
May
June
July
Aug
Sept
9/1/76
6/28/76
6/29/76
8/31/76
6/16/76
S
1M
2M
3M
Depth

FIGURE 21

Electrical Conductivity
below Fulmor Pool
(M-5)

——————— High Tide
----------- Low Tide



M-5
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
Electrical Conductivity (umhos/cm)
May
June
July
Aug
Sept
75-76
8/31/76
6/29/76
9/1/76
6/16/76
5/15/76
6/28/76
5/13/76
S
1M
2M
3M
Depth

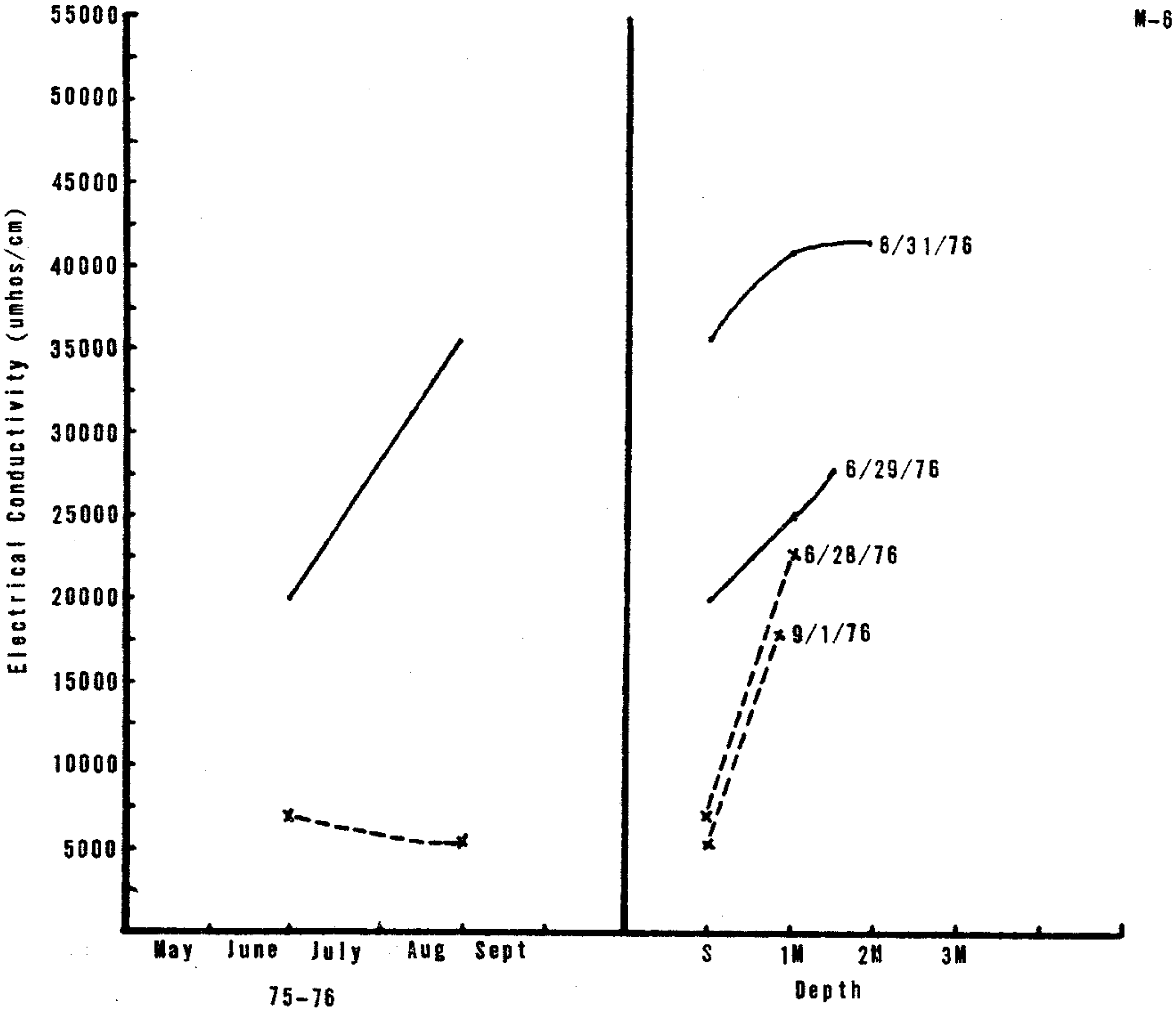

M-6
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
Electrical Conductivity (umhos/cm)
May
June
July
Aug
Sept
75-76
8/31/76
6/29/76
6/28/76
9/1/76
S
1M
2M
3M
Depth

FIGURE 23

Electrical Conductivity

in Channel North of Cock Robin Island

(M-7)

——————— High Tide

- - - - - - - - - - - Low Tide

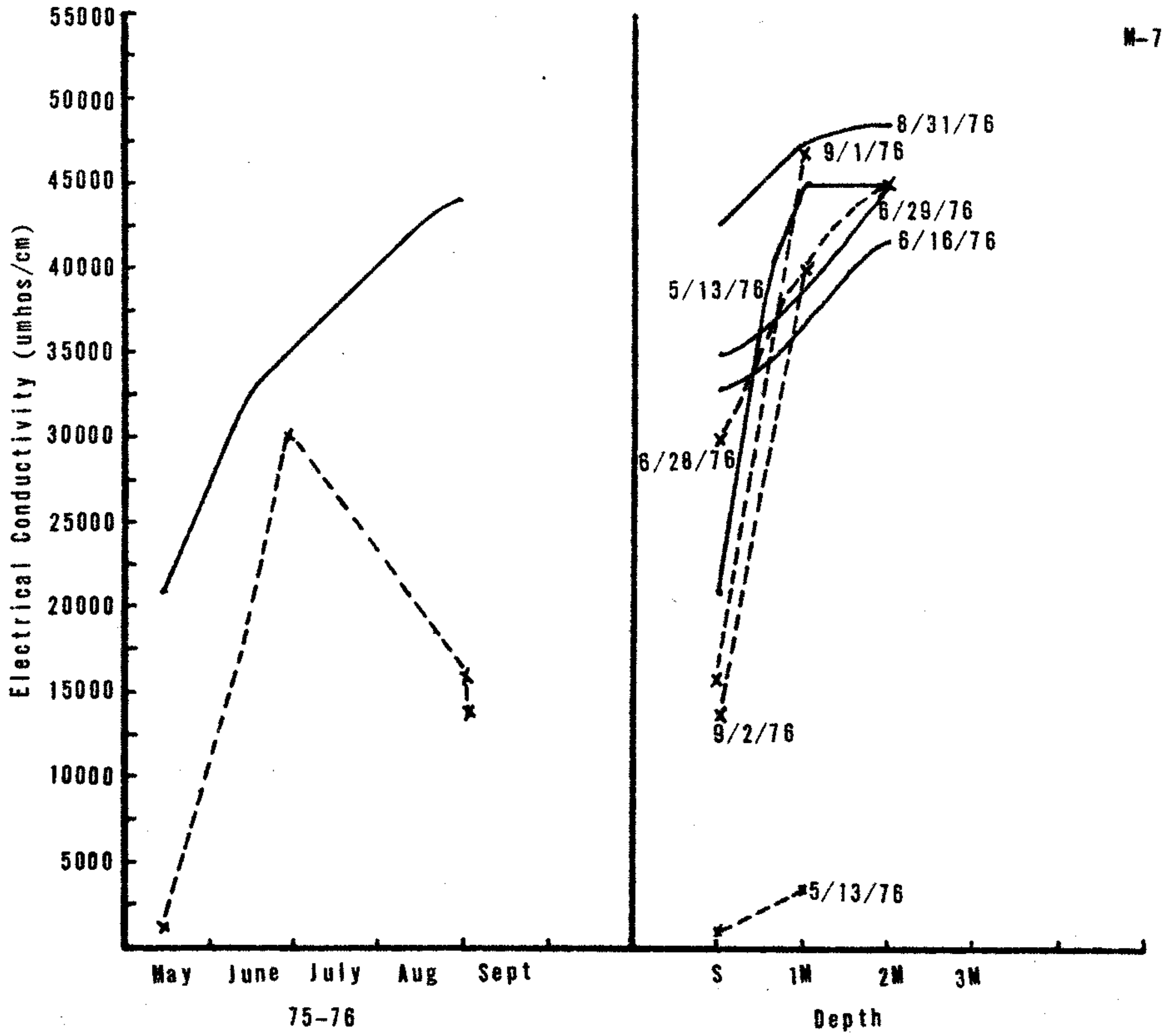

M-7
Electrical Conductivity (umhos/cm)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
May
June
July
Aug
Sept
75-76
S
1M
2M
3M
Depth
8/31/76
9/1/76
6/29/76
6/16/76
5/13/76
6/28/76
9/2/76
5/13/76

FIGURE 24

Electrical Conductivity

West of Cock Robin Island

(M-8)

——————— High Tide

----------- Low Tide

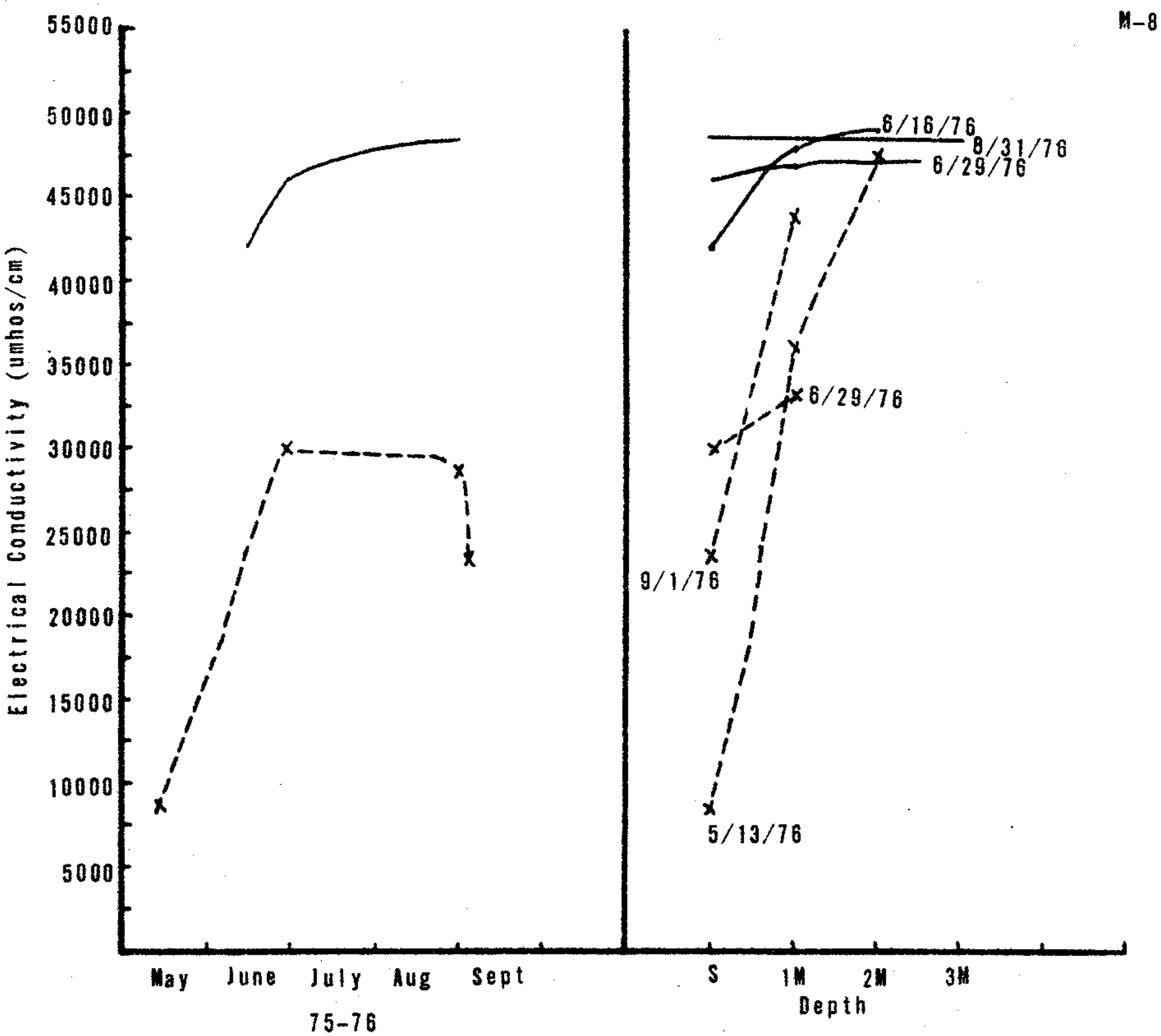
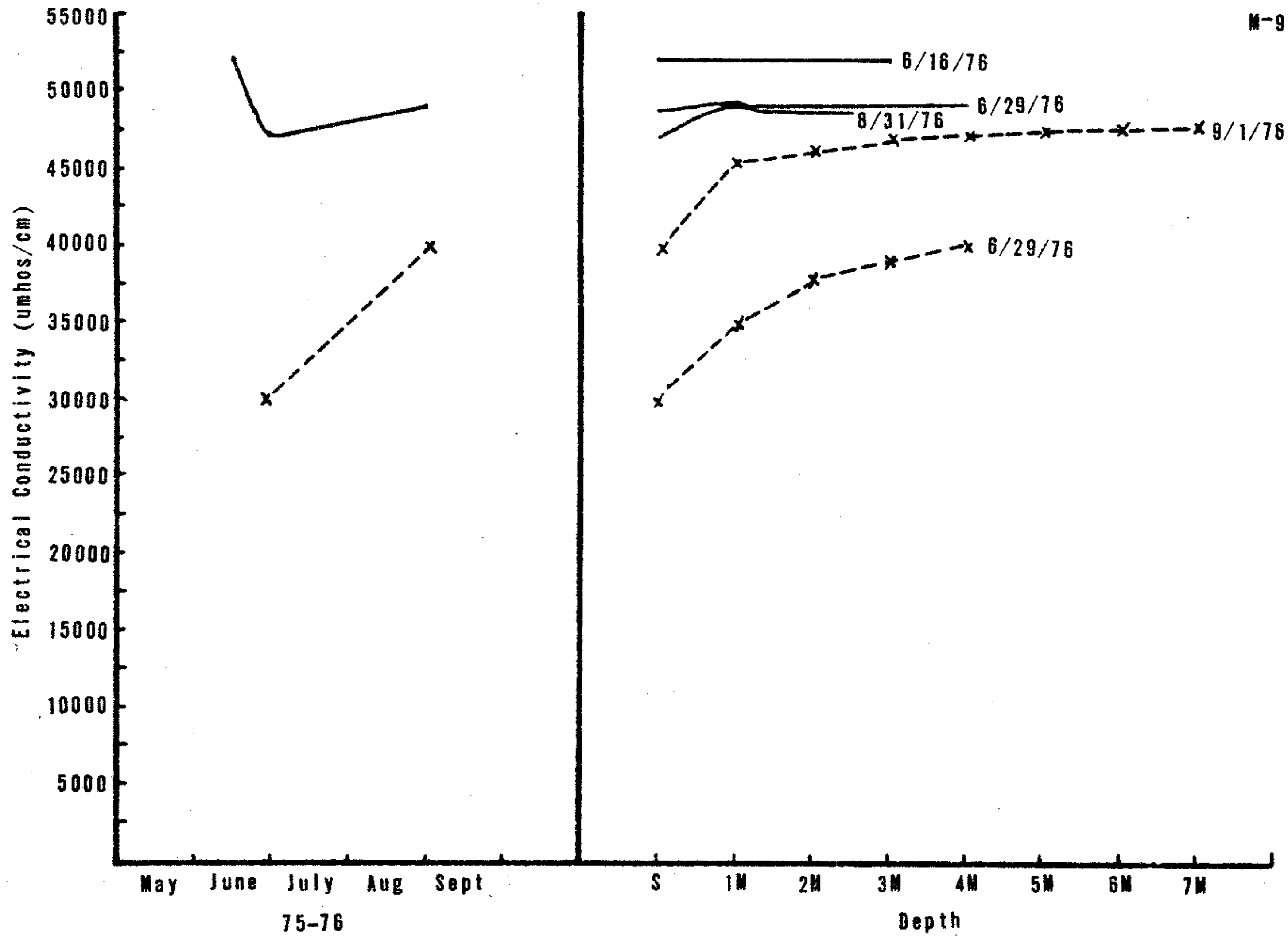

M-8
Electrical Conductivity (umhos/cm)
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
May
June
July
Aug
Sept
75-76
6/16/76
8/31/76
6/29/76
6/29/76
9/1/76
5/13/76
S
1M
2M
3M
Depth

FIGURE 25

Electrical Conductivity
at Mouth of Eel River Estuary
(M-9)

———————— High Tide
- - - - - - - - - - - Low Tide


M-9
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
Electrical Conductivity (umhos/cm)
May
June
July
Aug
Sept
75-76
6/16/76
6/29/76
8/31/76
9/1/76
6/29/76
S
1M
2M
3M
4M
5M
6M
7M
Depth

Temperature

Estuarine water temperature is influenced by a variety of factors, including air temperature, wind velocity, runoff water temperature, ocean temperature, and tidal stage. In general, water temperature fluctuations follow the same pattern as air temperature fluctuations, with the rapidity of change influenced by wind conditions. Ocean waters are generally cooler than river waters in the spring and summer, but may be warmer in the late fall and winter. The amount of interaction among these factors effect estuarine waters to produce highly variable temperatures.

In general, the temperature-tidal stage relationship is governed by the same mechanisms acting to control the EC-tidal stage relationship.

At upper McNulty Slough (n-1), little interaction occurs between low and high tides. Temperatures were higher during high tide, and lower during low tide (Figure 26). The high tide water temperatures are influenced mainly by air temperature and wind action to warm the water. The low tide water temperatures are influenced mainly by the colder salt water wedge. The maximum water temperature measured was 24°C (75°F), and occurred in June 1975, during high tide. The minimum recorded water temperature was 15°C (59°F), and occurred in October 1976, during low tide.

At Seven Mile Slough (n-5), Figure (27), the pattern is the same as at upper McNulty Slough (n-1). The maximum surface water temperature measured of the seven visits was 23°C (73.5°F), and occurred in July 1975 during high tide. The minimum temperature was 16.4°C (61.5°F), and occurred in August 1975, during low tide. This low tide was preceded by an exceptional high tide (7.2 ft.), which allowed greater intrusion of colder saline waters, resulting in a low temperature measurement during an otherwise warm period.

The pattern was also the same at Quill Slough (n-4), (Figure 26) during the early summer of 1975, but not during late summer 1975, nor 1976. During early summer 1975, the maximum recorded water temperature was 22.8°C (73°F), and occurred in July during high tide. The minimum recorded water temperature during this period was 16.1°C (61°F), and occurred in June during low tide. During 1976 little water mixing occurred between high and low tides, and water movement consisted of back and forth motion. This would allow stretches of water not undergoing much exchange to warm to a greater extent than stretches having some exchange. The higher the stretch in the system, the less the exchange, and the greater the warming. The tidal fluxes mostly serve to move these stretches of water back and forth. During high tide, cooler water from a lower reach undergoing greater exchange is moved up the sloughs, forcing the warmer water stretch to move further up the slough. During low tide, the cooler water stretch recedes, allowing the warmer water stretch to recede also. Because of this kind of water movement, high tide water temperatures were cooler than those from low tide measurements at Quill Slough during 1976.

The same type of water-movement-temperature relationship that occurred in Quill Slough in 1976 occurred during 1975 and 1976 for all other stations in the estuary, except those undergoing the greatest domination by freshwater (Stations m-1, 2, and 3).

In general, the closer the station to the mouth of the estuary, the lower were the temperatures (Figures 26 through 30). Mixing with tidal water was very important in maintaining cooler water temperatures during the summer months in the lower reaches of the estuary. But, in increasingly higher reaches, temperature control becomes more and more dominated by the influence of freshwater flow. At Station m-2, early summer temperature patterns were the same as at Quill Slough. But in late summer, the reverse of the pattern was occurring. The high tide stage brought up warmer water, and the low tide allowed cooler water to move down. The pools immediately below this station undergo little water exchange. This region also receives more heat due to its distance further inland, and, therefore, more fog-free periods. The combination of these two factors allows the pool areas to heat. During late summer these pools become warmer than the river water. At high tide, the warmer water of the pools is forced upstream, where some mixing does occur, but not enough to prevent the temperature from increasing. At low tide, the stations become dominated by the cooler water of the river.

The same type of interaction occurs at Stations m-3 and probably m-1, although no low tide data is available for Station m-1.

Figure 26

Surface Water Temperatures at Various
Stations and Dates in the Eel River Estuary

————	high tide, 1975
o————o	low tide, 1975
- - - - -	high tide, 1976
o - - - o	low tide, 1976

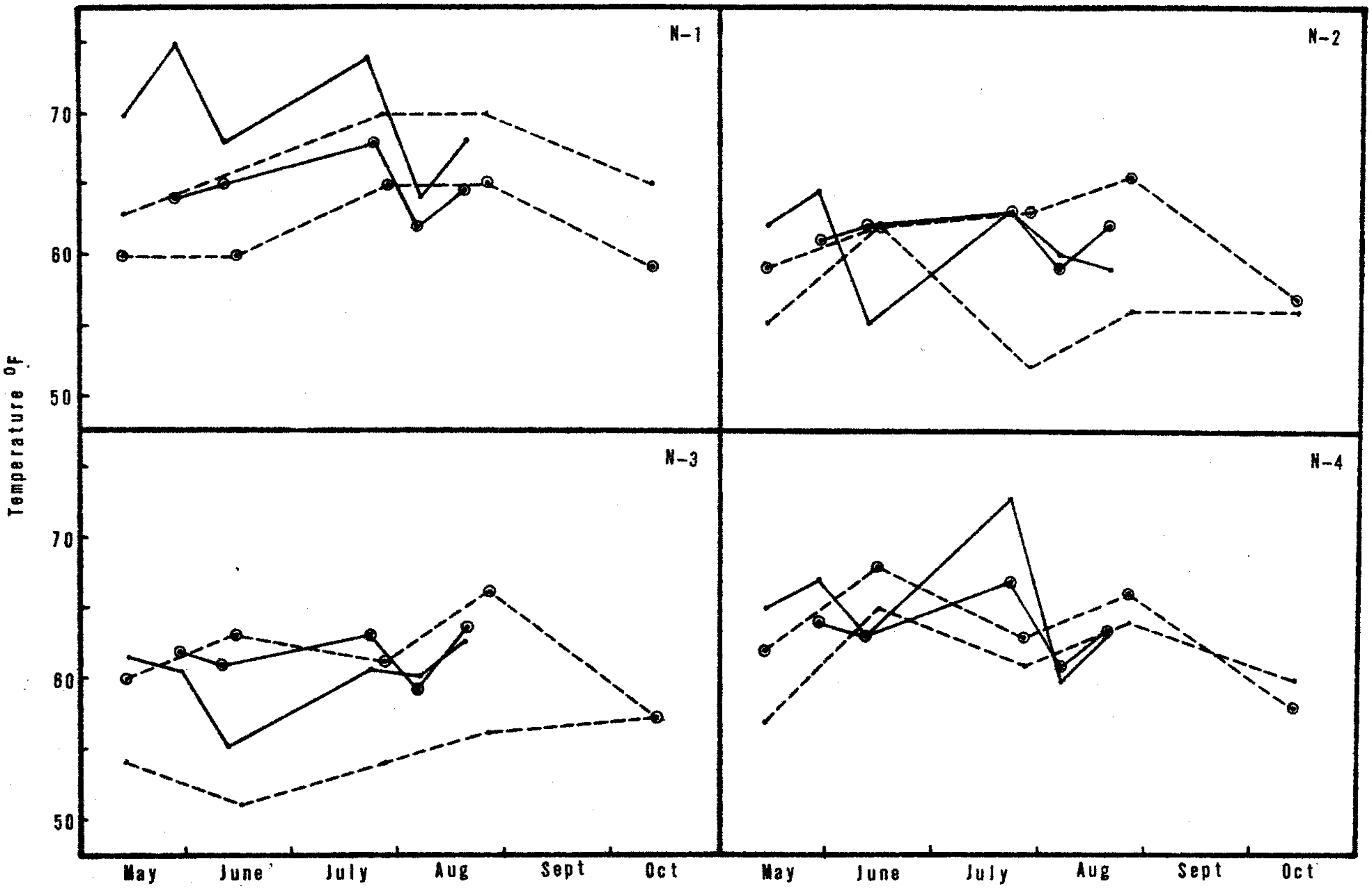

N-1
N-2
N-3
N-4
Temperature °F
70
60
50
70
60
50
May
June
July
Aug
Sept
Oct
May
June
July
Aug
Sept
Oct

FIGURE 27

Surface Water Temperatures at Various
Stations and Dates in the Eel River Estuary

————	high tide, 1975
o————o	low tide, 1975
- - - - -	high tide, 1976
o - - - o	low tide, 1976

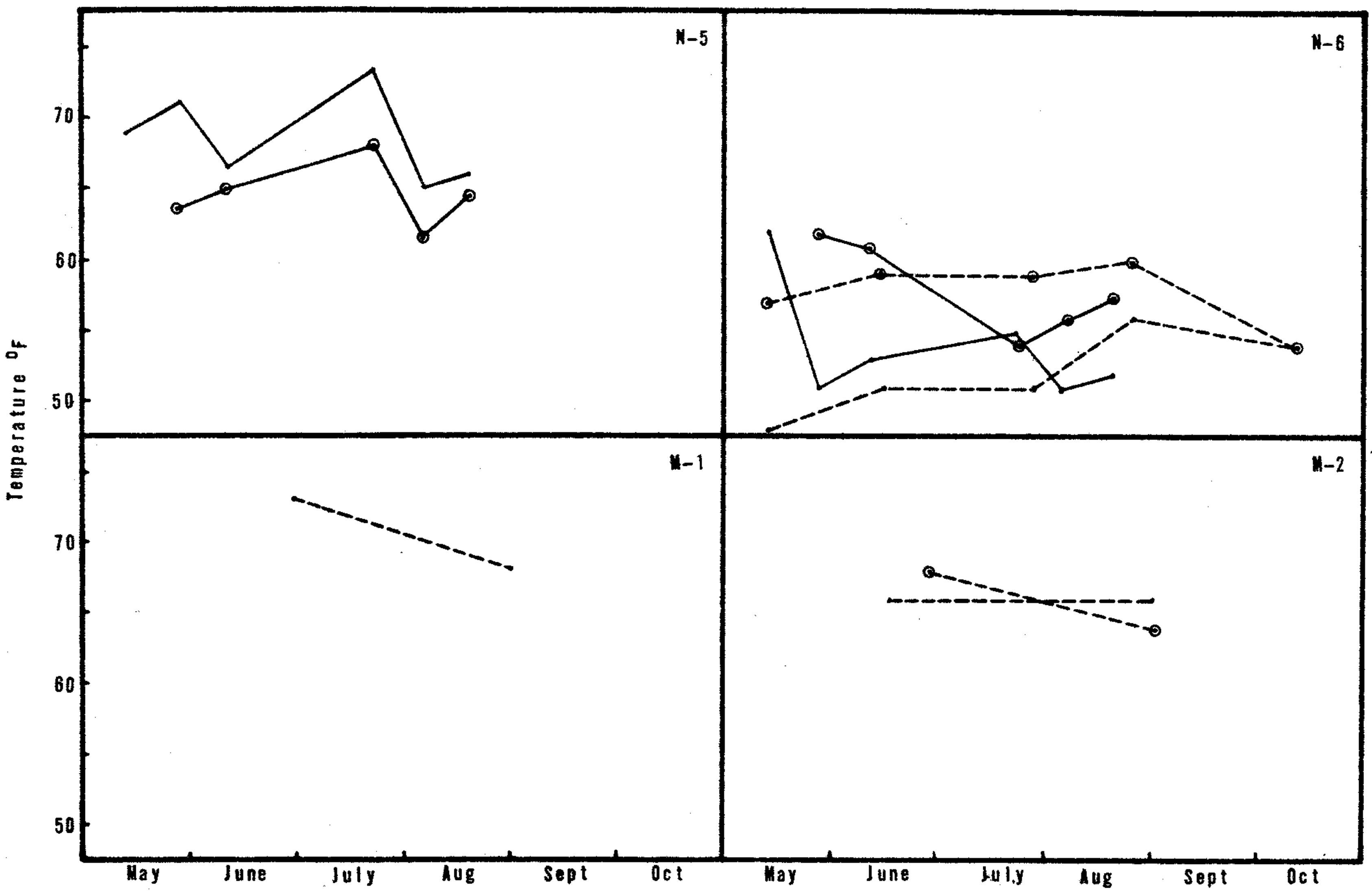
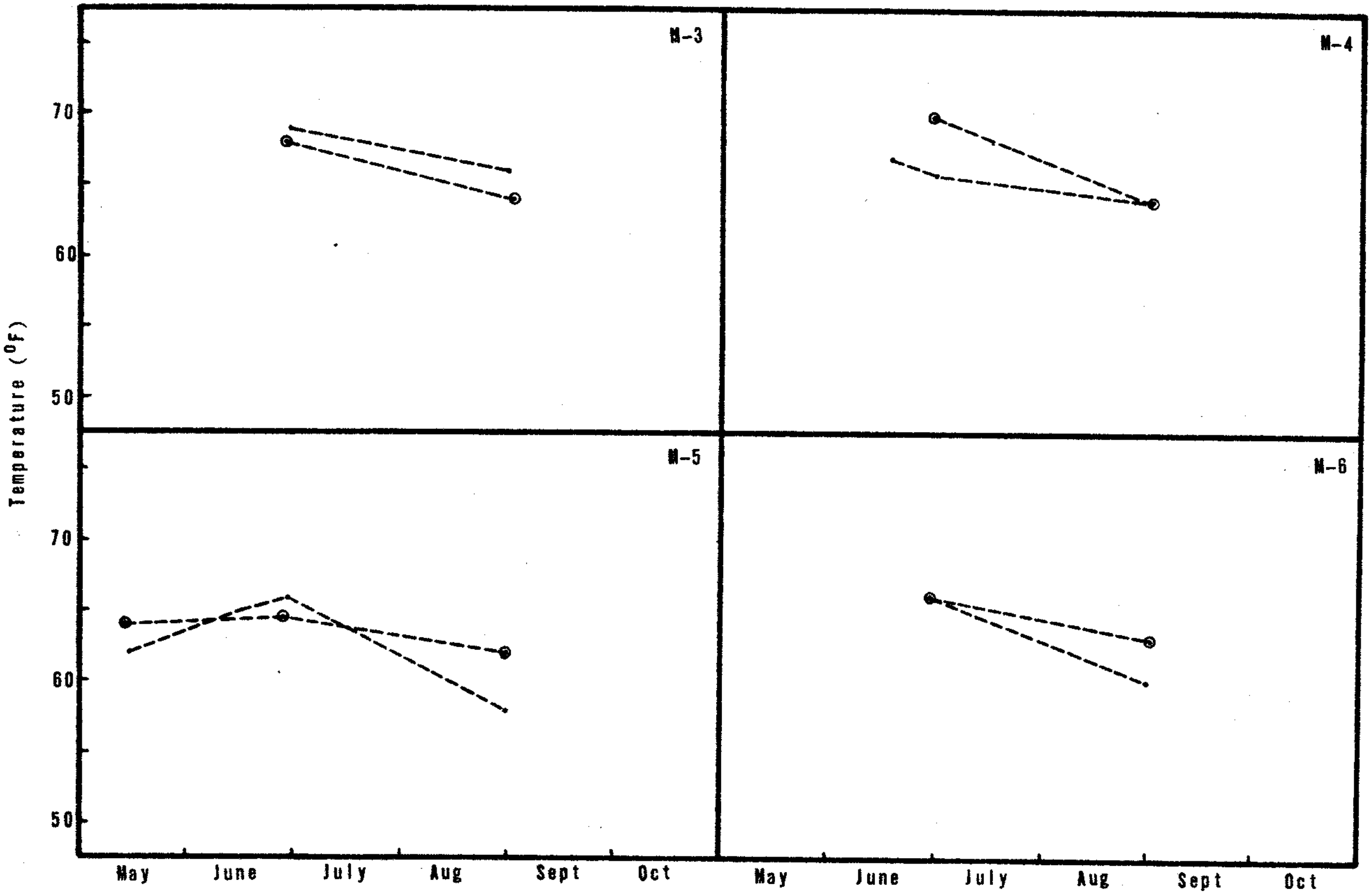

N-5
N-6
M-1
M-2
Temperature °F
70
60
50
70
60
50
May
June
July
Aug
Sept
Oct
May
June
July
Aug
Sept
Oct

FIGURE 28

Surface Water Temperatures at Various
Stations and Dates in the Eel River Estuary

————	high tide, 1975
o————o	low tide, 1975
- - - - -	high tide, 1976
o - - - o	low tide, 1976


M-3
M-4
M-5
M-6
Temperature (°F)
70
60
50
70
60
50
May
June
July
Aug
Sept
Oct
May
June
July
Aug
Sept
Oct

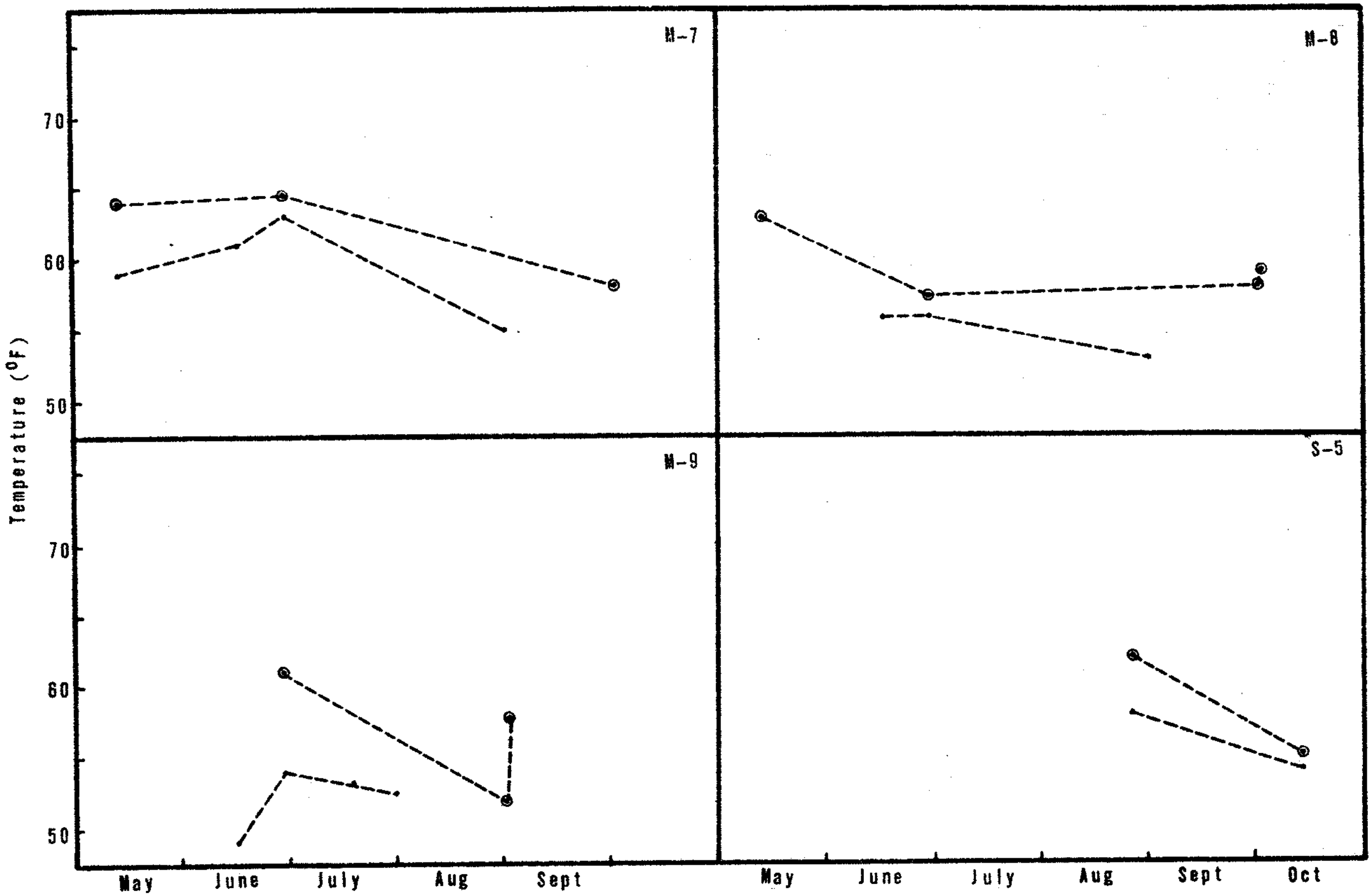
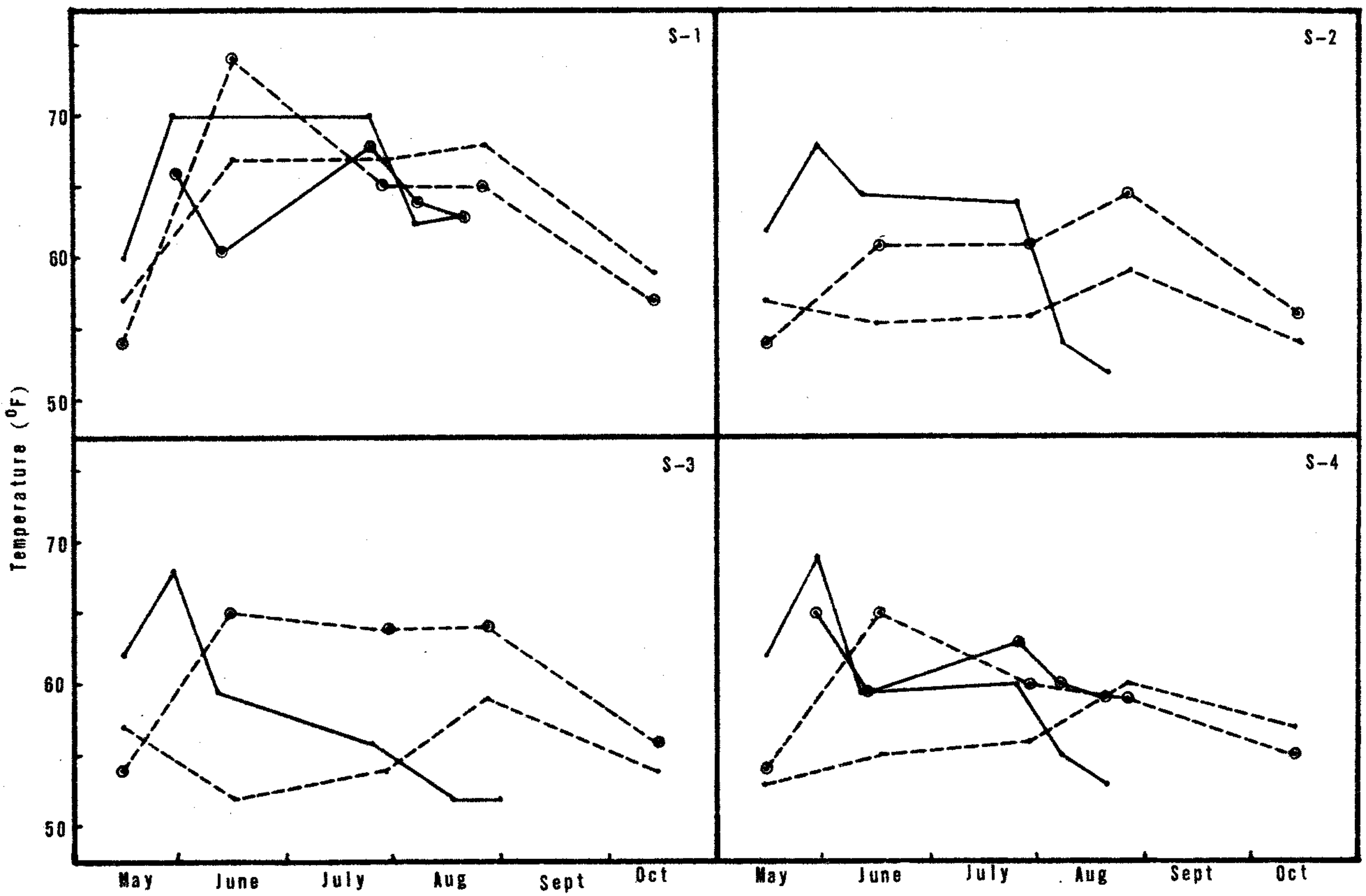

M-7
M-8
M-9
S-5
Temperature (°F)
70
60
50
70
60
50
May
June
July
Aug
Sept
May
June
July
Aug
Sept
Oct

FIGURE 30

Surface Water Temperatures at Various
Stations and Dates in the Eel River Estuary

———	high tide, 1975
o———o	low tide, 1975
- - - - -	high tide, 1976
o - - - o	low tide, 1976


S-1
S-2
S-3
S-4
Temperature (°F)
70
60
50
70
60
50
May
June
July
Aug
Sept
Oct
May
June
July
Aug
Sept
Oct

Dissolved Oxygen

Dissolved oxygen concentrations exhibited great variation between stations and at the same station under different flow and tide stages (Table 1). But generally, high tide D.O. levels were higher than the low tide D.O. levels at all stations (Figures 31 through 35). Also, D.O. levels were generally higher and exhibited less fluctuation between tide levels at both Crab Park and the main channel of the estuary.

Dissolved oxygen levels at low tide of all sloughs on the north side and of two sloughs on the south side were below the minimum desirable level of 5.0 mg/l (SWRCB 1975) at some time during this study. In addition, two sloughs on the north side were below this level at some time during high tide. All these low D.O. values were obtained in the mid-to-late summer months.

TABLE 1

DISSOLVED OXYGEN LEVELS AT VARIOUS LOCATIONS IN THE EEL RIVER ESTUARY BETWEEN MAY 1974 AND OCTOBER 1976

Location	Low Tide Range	High Tide Range
Upper McNulty (N-1)	2.8-6.4	4.8-11.5
McNulty at Mouth (N-2)	4.3-9.1	7.7-10.5
Hawk at Mouth (N-3)	4.6-9.4	7.8-11.0
Quill Slough (N-4)	4.5-8.9	5.6-11.0
Seven-Mile Slough (N-5)	4.0-5.8	4.8-10.9
Crab Park (N-6)	7.2-12.1	9.0-11.7
Upper Salt River (S-1)	4.1-8.6	5.8-10.0
Cutoff Slough (S-2)	6.3-11.4	8.6-11.4
Salt River (S-2)	5.5-10.7	8.2-11.0
Morgan Slough (S-4)	4.5-10.0	8.4-12.2
South Bay at Mouth (S-5)	6.5-8.5	8.2-9.8
(M-1)	-	9.3-12.0
(M-2)	7.8	7.9-8.2
(M-3)	7.8-9.5	9.3-10.0
(M-4)	7.8-9.5	8.7-10.0
(M-5)	8.6-10.5	9.0-10.0
(M-6)	7.4-9.8	9.0-10.0
(M-7)	7.8-10.2	9.1-11.5
(M-8)	8.0-8.6	7.5-11.0
(M-9)	7.2-12.1	9.0-11.7

It is difficult to determine the specific circumstances that lead to the formation of these D.O. levels. Among the factors that could be responsible are (1) low flushing flows in the sloughs, coupled with (2) high levels of decomposing organic materials, (3) irrigation waste waters, and (4) farm or dairy processing wastes. Little or no information has been gathered concerning any of these possible causes. Although flows in the main channel have little to do with the flushing of sloughs, the general runoff patterns should coincide. Therefore, low D.O. conditions in the sloughs can be seen to correspond to low flow conditions in the main channel (Figures 6 and 31 through 35). It is thus apparent that the low flow in the sloughs would allow any of the other previously mentioned factors to exert an oxygen demand. Low D.O. values are not as commonly found at high tide as at low tide, probably because of mixing and flushing by the high tide, except in the higher reaches of the sloughs.

FIGURE 31

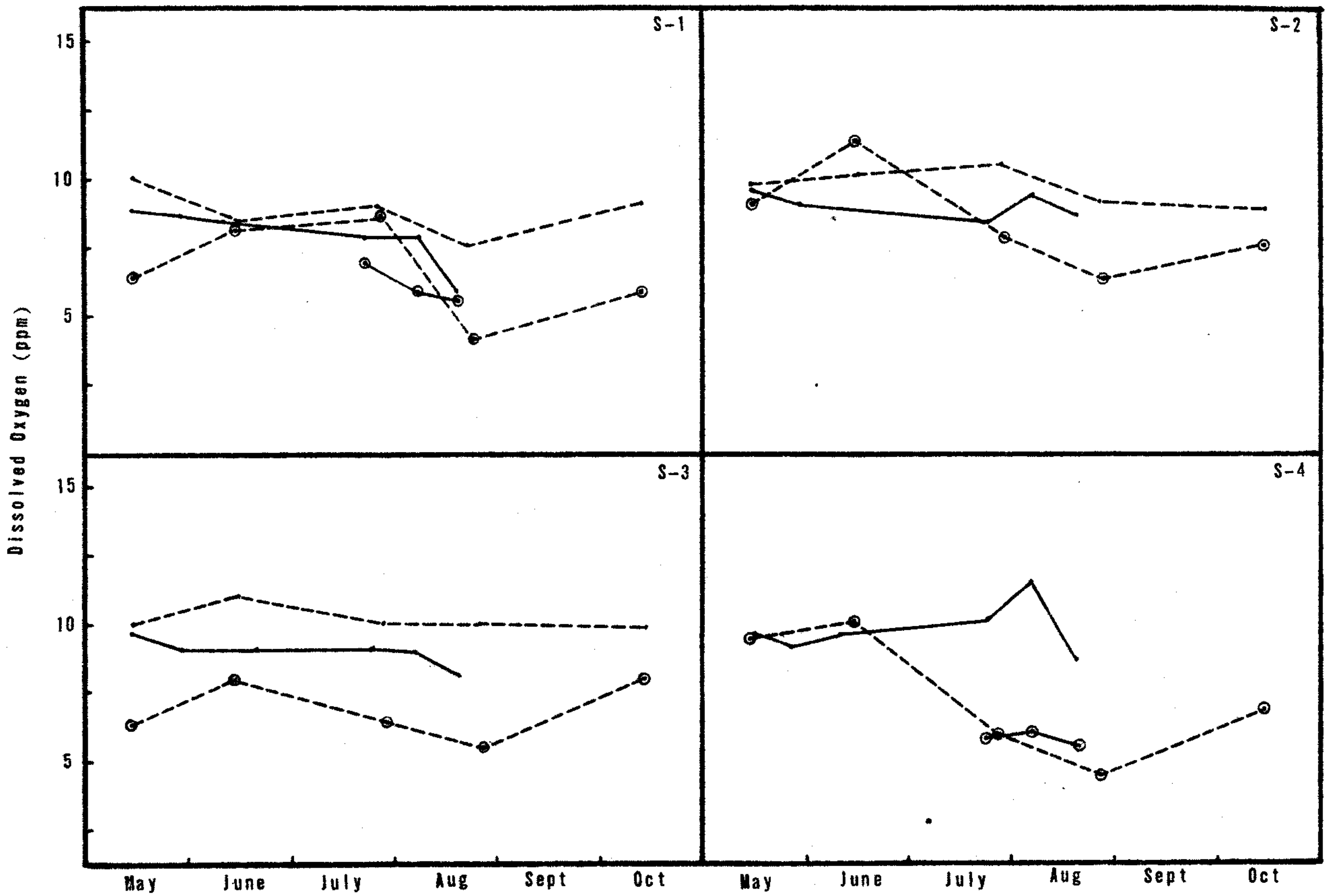
Dissolved Oxygen Concentrations at
Various Stations and Dates in the Eel River Estuary

———— high tide, 1975

o————o low tide, 1975

- - - - - high tide, 1976

o - - - o low tide, 1976



S-1
S-2
S-3
S-4
Dissolved Oxygen (ppm)
15
10
5
May
June
July
Aug
Sept
Oct

FIGURE 32

Dissolved Oxygen Concentrations at
Various Stations and Dates in the Eel River Estuary

———	high tide, 1975
o———o	low tide, 1975
- - - - -	high tide, 1976
o - - - o	low tide, 1976

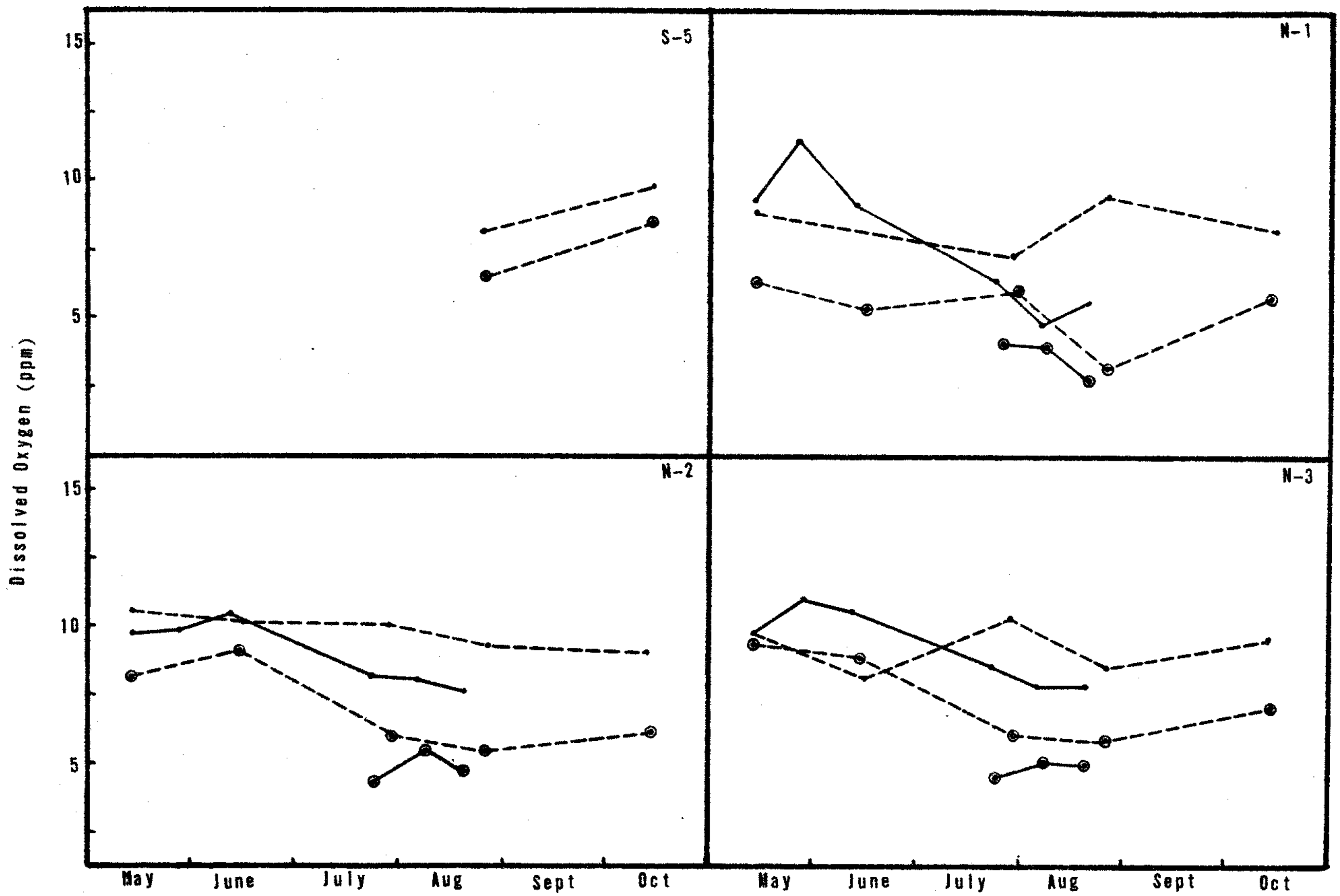
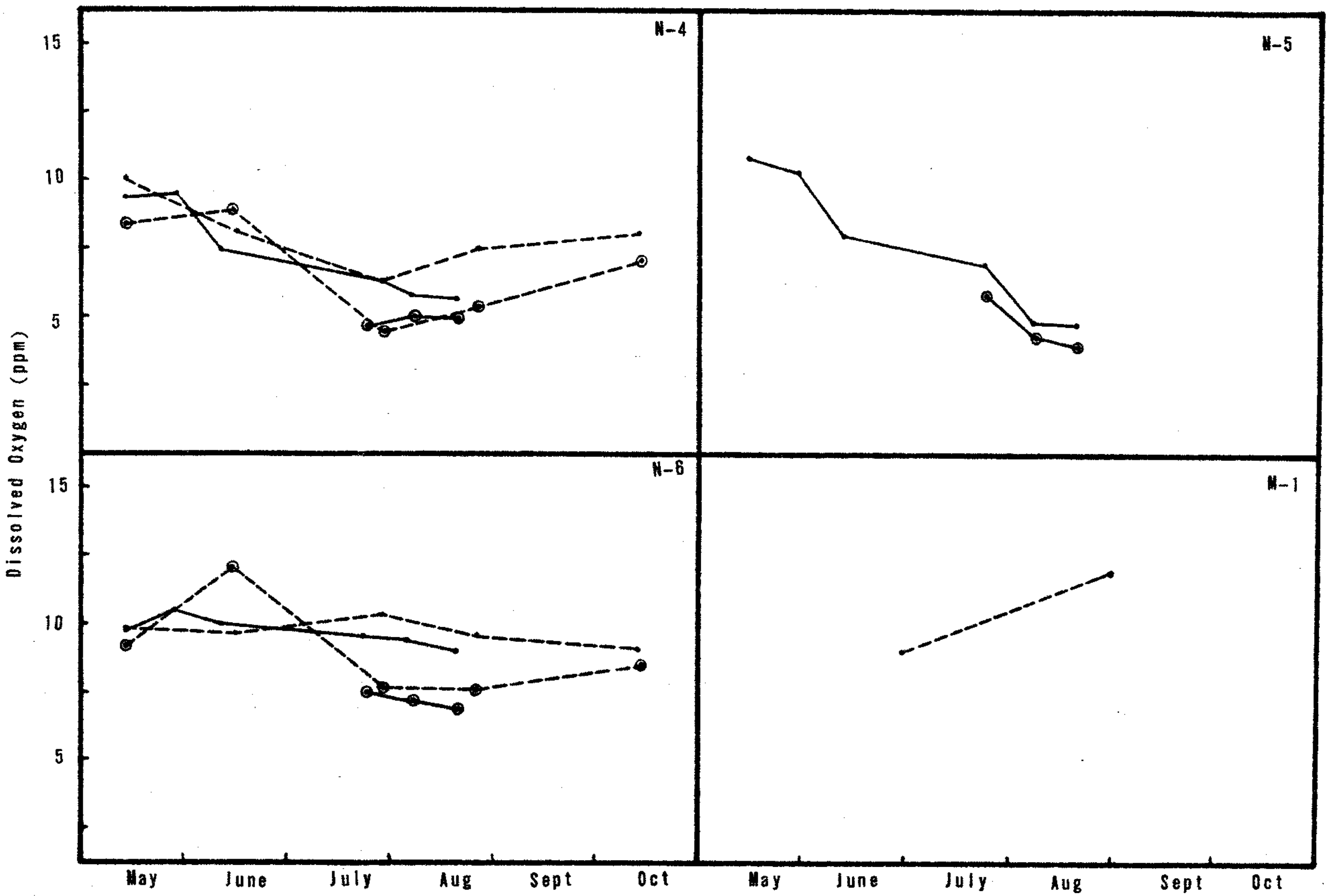

S-5
N-1
N-2
N-3
Dissolved Oxygen (ppm)
15
10
5
15
10
5
May
June
July
Aug
Sept
Oct
May
June
July
Aug
Sept
Oct

FIGURE 33

Dissolved Oxygen Concentrations at
Various Stations and Dates in the Eel River Estuary

————	high tide, 1975
o————o	low tide, 1975
- - - - -	high tide, 1976
o - - - o	low tide, 1976



N-4
N-5
N-6
M-1
Dissolved Oxygen (ppm)
15
10
5
May
June
July
Aug
Sept
Oct

FIGURE 34

Dissolved Oxygen Concentrations at
Various Stations and Dates in the Eel River Estuary

————	high tide, 1975
o————o	low tide, 1975
- - - - -	high tide, 1976
o - - - o	low tide, 1976

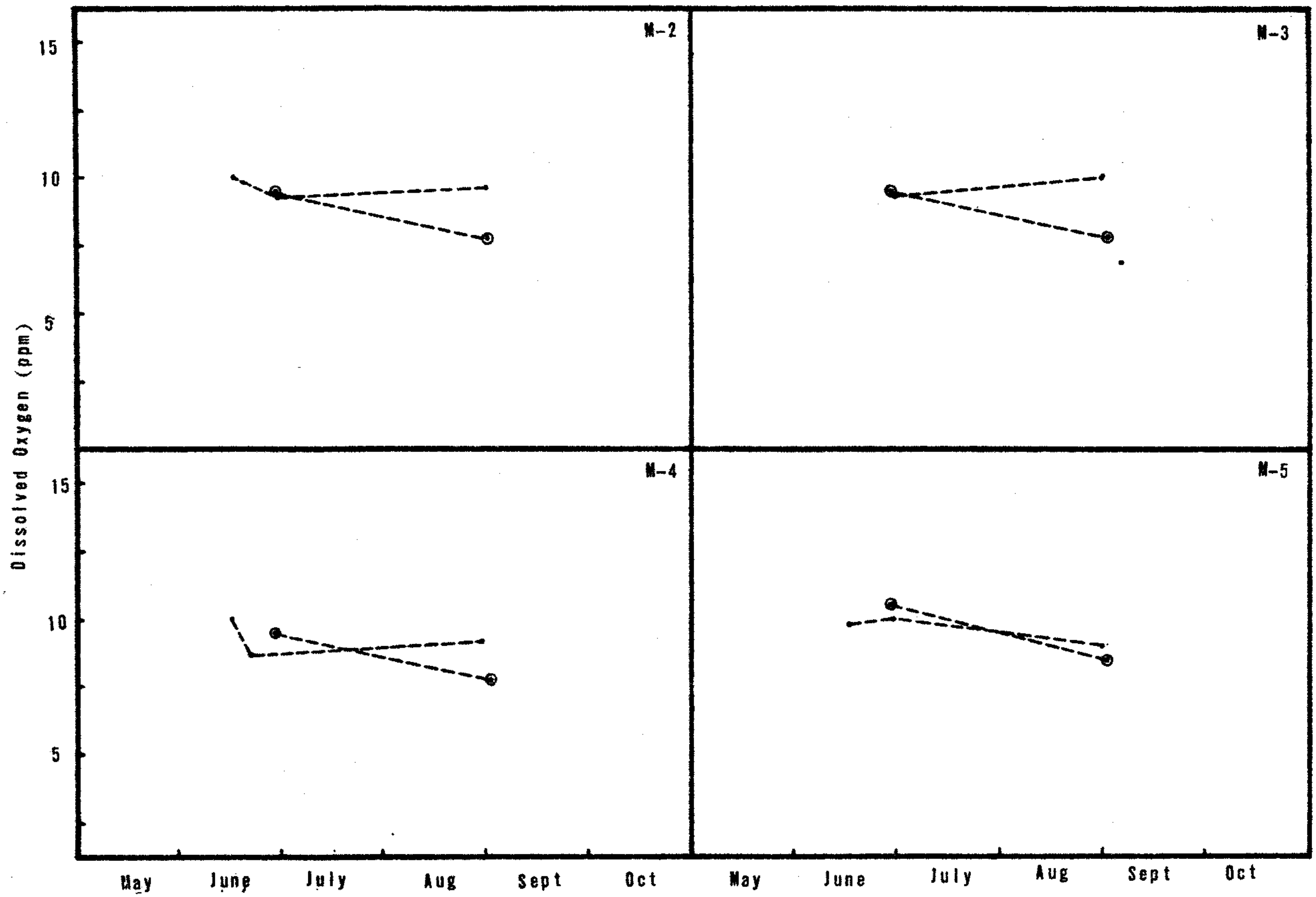
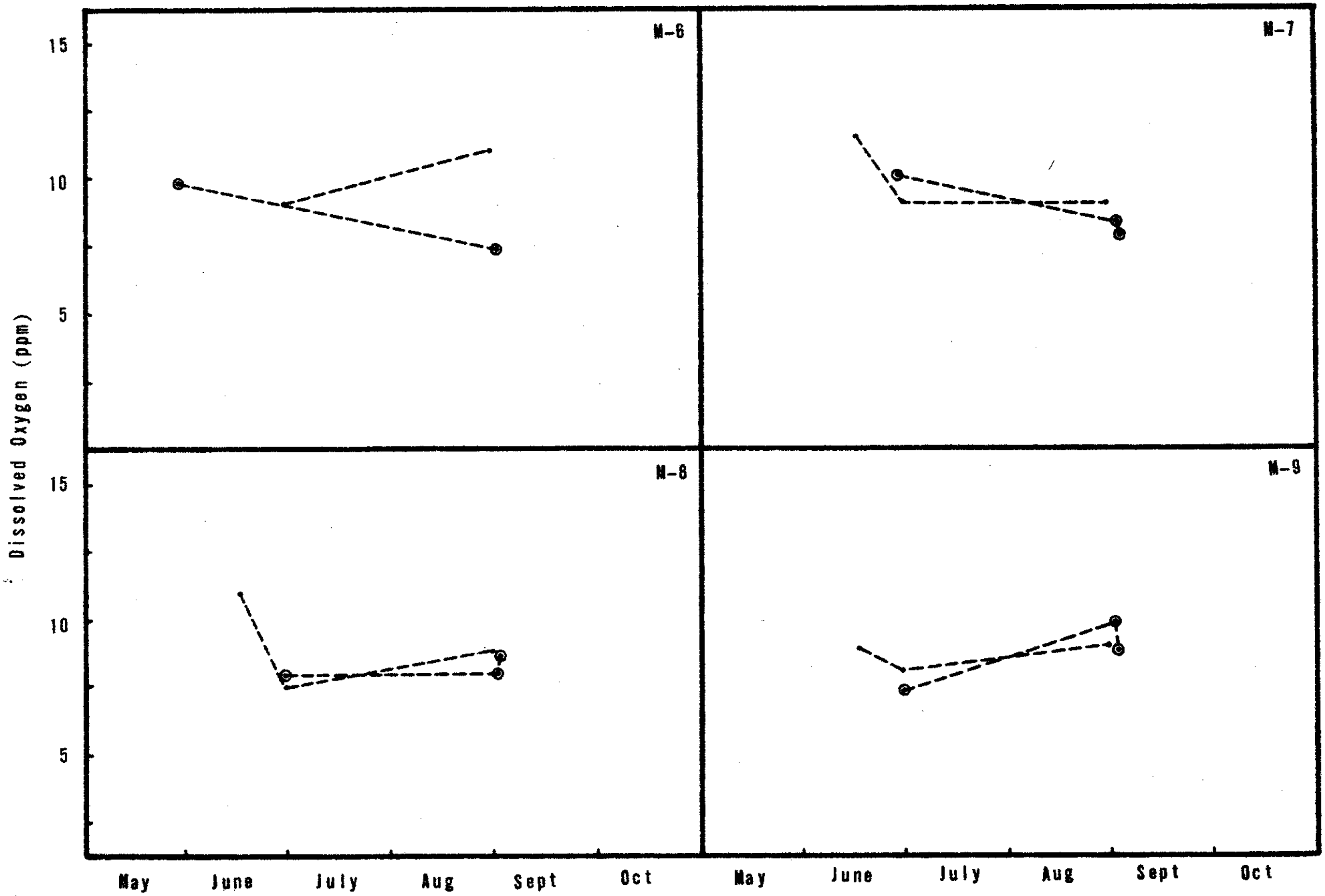

M-2
M-3
M-4
M-5
Dissolved Oxygen (ppm)
15
10
5
15
10
5
May
June
July
Aug
Sept
Oct
May
June
July
Aug
Sept
Oct

FIGURE 35

Dissolved Oxygen Concentrations at
Various Stations and Dates in the Eel River Estuary

———————	high tide, 1975
o———————o	low tide, 1975
- - - - -	high tide, 1976
o - - - o	low tide, 1976



Dissolved Oxygen (ppm)
15
10
5
M-6
M-7
M-8
M-9
May
June
July
Aug
Sept
Oct

pH

pH levels remained within the desirable range of 6.5 to 8.5 (SWRCB 1975) for all stations throughout the study period (Table 2). The highest pH recorded was in May 1974 during which a value of 8.4 was found at several stations at high tide. The lowest pH recorded was in May 1976, during which a value of 7.2 was found in the Salt River (s-3). Higher pH values were found at high tide than at low tide for all stations, indicating the influence of ocean water. The greater the influence of ocean water, the less the pH fluctuations were between high and low tides, and the higher was the pH value. Lower pH values in the upper reaches of the estuary could be due to any of the factors also affecting the D.O. levels.

TABLE 2

pH LEVELS AT VARIOUS LOCATIONS IN THE EEL RIVER ESTUARY BETWEEN MAY 1974 AND OCTOBER 1976

Location	Low Tide Range	High Tide Range
Upper McNulty (N-1)	7.4-7.9	8.0-8.2
McNulty at Mouth (N-2)	7.8-8.3	8.1-8.4
Hawk at Mouth (N-3)	7.8-8.2	8.1-8.2
Quill Slough (N-4)	7.6-8.3	7.7-8.4
Seven Mile Slough (N-5)	-	-
Crab Park (N-6)	7.8-8.6	8.0-8.4
Upper Salt River (S-1)	7.2-7.9	7.9-8.2
Cutoff Slough (S-2)	7.9-8.5	7.9-8.4
Salt River (S-3)	7.2-8.1	7.9-8.4
Morgan Slough (S-4)	7.6-8.2	8.0-8.2
South Bay at Mouth (S-5)	8.0-8.1	8.1-8.2
(M-1)	-	7.8-8.2
(M-2)	7.5-7.8	7.6-8.2
(M-3)	7.5-8.0	7.8-7.9
(M-4)	7.5-7.9	7.6-8.2
(M-5)	7.6-7.9	7.9-8.1
(M-6)	7.6-7.9	7.9
(M-7)	7.5-8.0	8.0-8.3
(M-8)	7.7-8.0	8.1-8.2
(M-9)	7.8-8.2	8.1-8.2

Turbidity

Water turbidity was highly variable between stations and with time at the same station (Figures 36-38). In general, turbidity levels were highest during the winter and spring periods of high runoff, and lowest in summer and fall. In most cases turbidity was higher during low tide than at high tide.

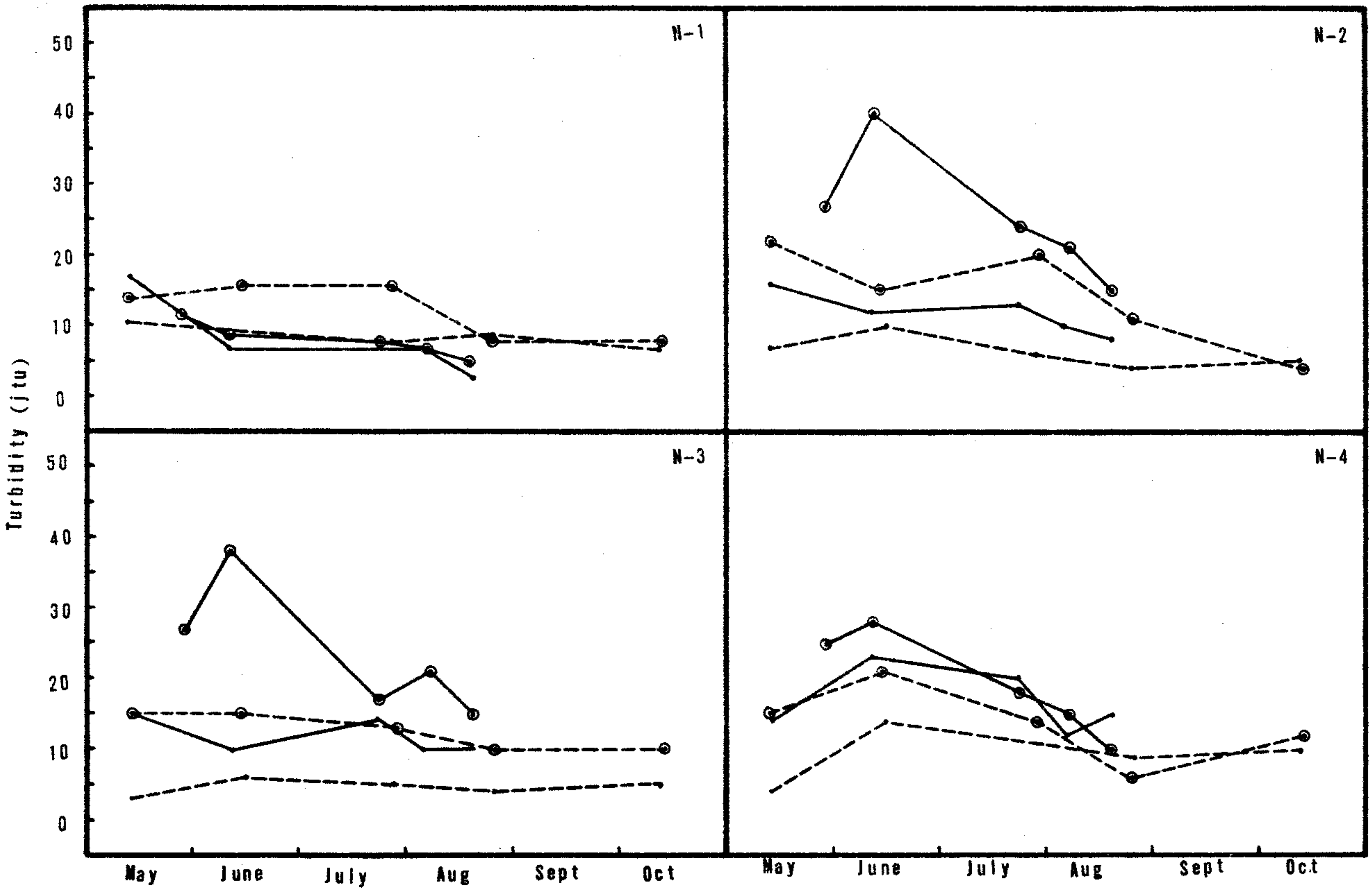
Turbidity values for the summer months ranged from a high of 54 JTU at Crab Park (n-6) during June 1975 to a low of 1 JTU at Cutoff (s-2) and Morgan (s-4) Sloughs in August 1976. Differences between turbidity levels at different tidal stages ranged from no difference at upper McNulty Slough (n-1) during May and August 1975 to 48 JTU at Crab Park during June 1975.

Turbidity is affected not only by runoff and tidal conditions, but also by in-channel disturbances and drainage waters from agriculture or industry. In-channel disturbances could be caused either by the activities of estuary water inhabitants, such as fish, crabs, or otter, or by non-water inhabitants, including deer, birds, or man. Because of these factors all acting to produce turbidity, patterns associated with natural runoff and tidal conditions cannot be evaluated to any further extent with the limited data collected.

FIGURE 36

Surface Turbidity at Various Stations
and Dates in the Eel River Estuary

————	high tide, 1975
o————o	low tide, 1975
- - - - -	high tide, 1976
o - - - o	low tide, 1976



N-1
N-2
N-3
N-4
Turbidity (jtu)
50
40
30
20
10
0
May
June
July
Aug
Sept
Oct

FIGURE 37

Surface Turbidity at Various Stations
and Dates in the Eel River Estuary

———	high tide, 1975
o———o	low tide, 1975
- - - - -	high tide, 1976
o - - - o	low tide, 1976

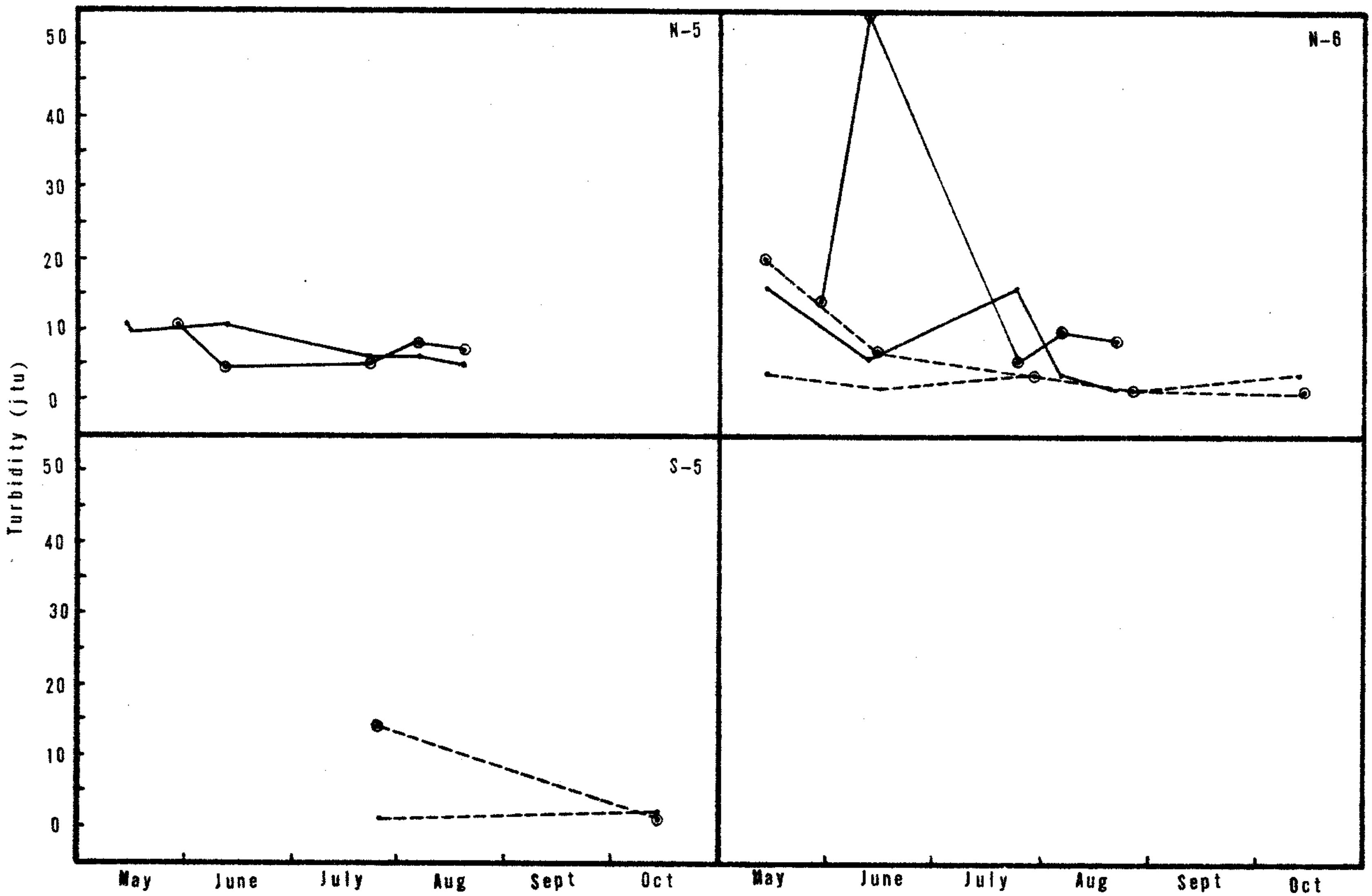

N-5
N-6
S-5
Turbidity (jtu)
50
40
30
20
10
0
May
June
July
Aug
Sept
Oct

FIGURE 38

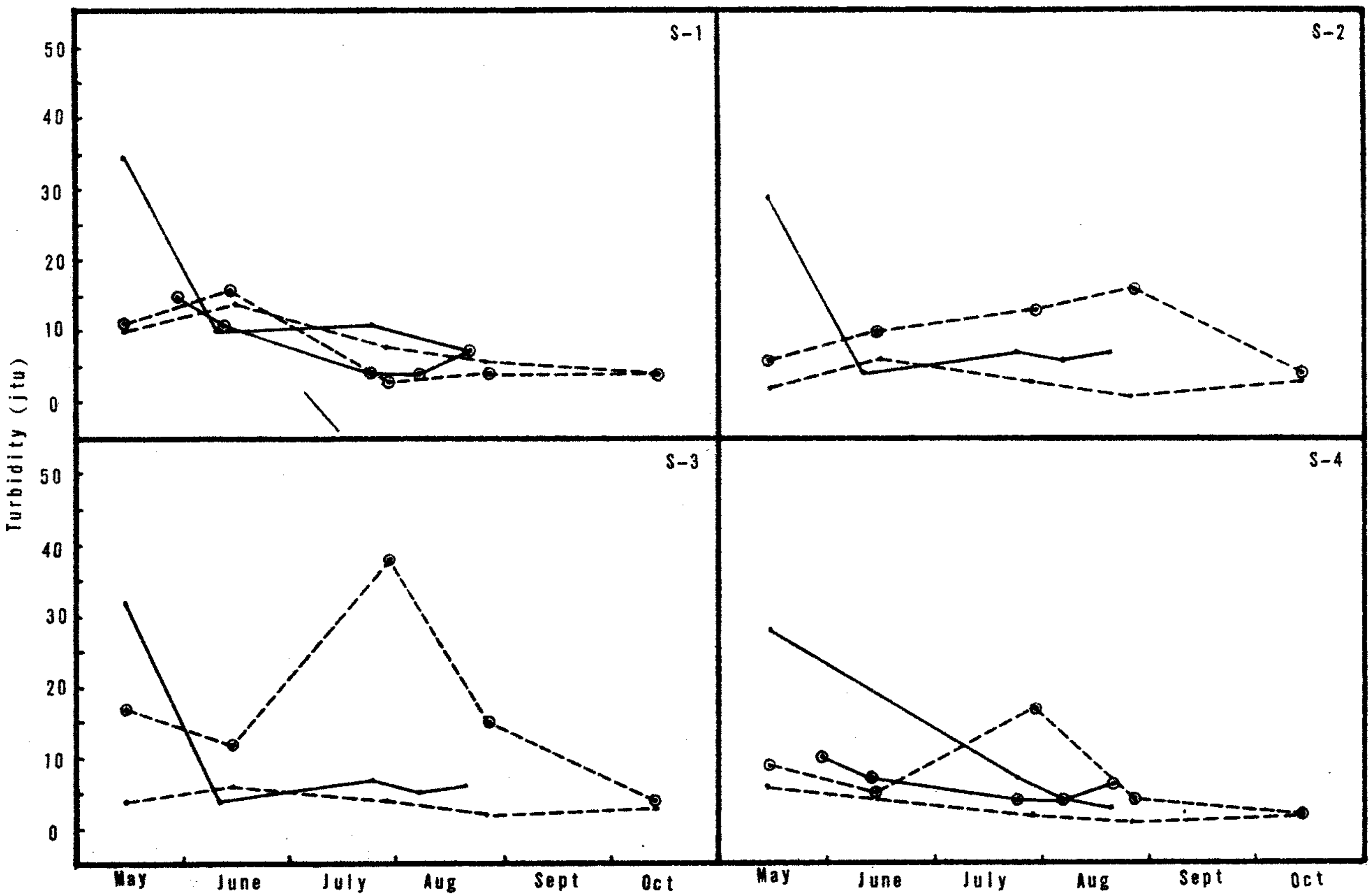
Surface Turbidity at Various Stations and Dates in the Eel River Estuary

——— high tide, 1975

o———o low tide, 1975

- - - - - high tide, 1976

o - - - o low tide, 1976


S-1
S-2
S-3
S-4
Turbidity (jtu)
50
40
30
20
10
0
May
June
July
Aug
Sept
Oct

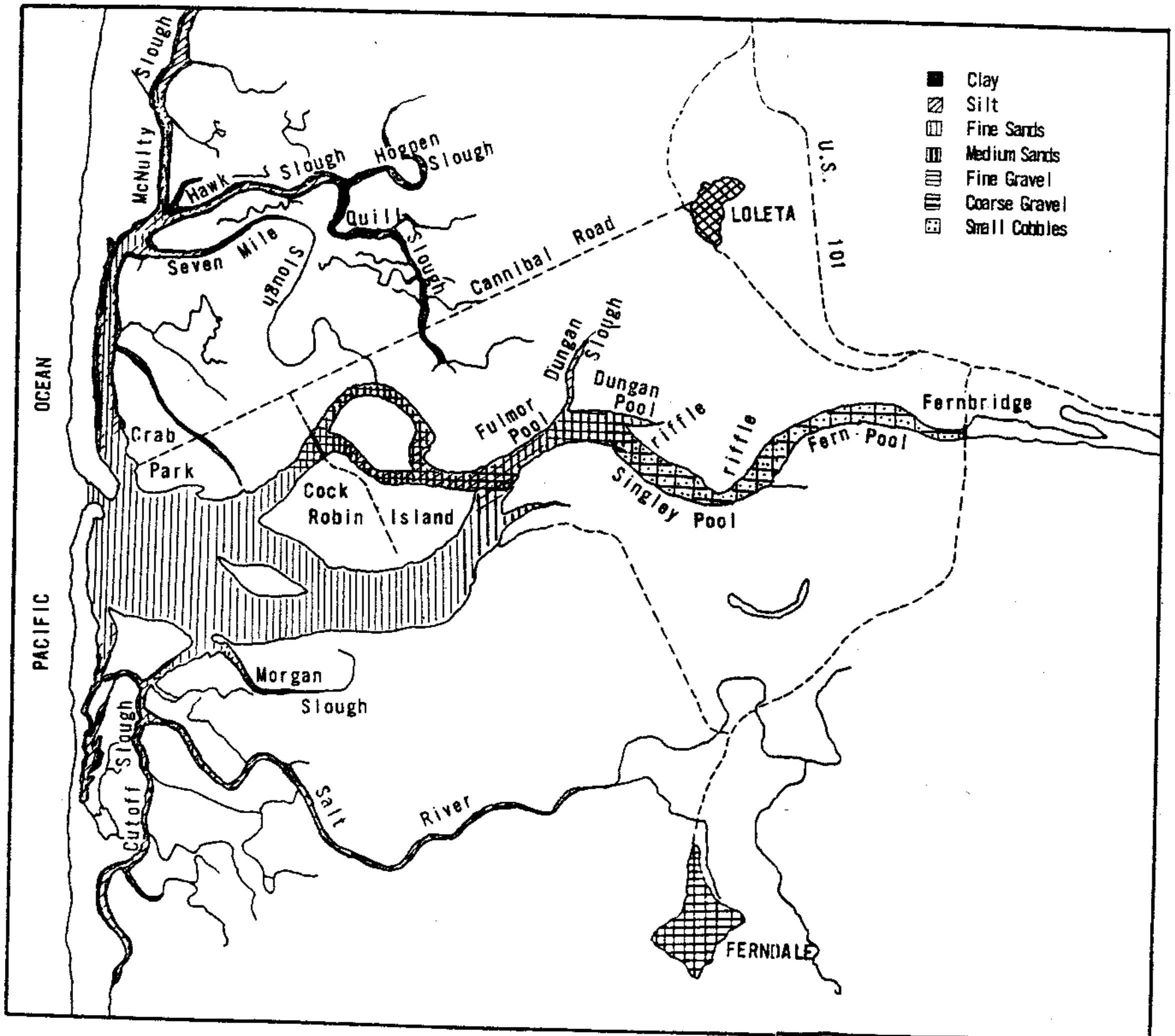
Soil Analysis

At the mouth of the estuary (m-9), the bottom material is composed of well-graded clean sands (Figure 39). This material is gradually replaced in upper reaches of the main channel so that at the Cock Robin Island Bridge the bottom materials are silty fine sands with fine gravels. Between the bridge and the east end of the island, the bottom materials become silty medium sands with fine gravels. At the east end of the island the materials are medium sand with coarse gravels. Fulmor Pool is composed of silty sands. At the mouth of Dungan Slough the materials are fine gravelly sands. Dungan Pool contains sandy fine gravels. At the head of this pool the bottom materials are sandy coarse gravels. The bottom materials upstream from the head of Dungan Pool to Fernbridge are sandy coarse gravels with small cobbles.

Bottom materials of the North Bay, Salt River, and all sloughs follow generally the same pattern. At the mouth of the North Bay and Salt River the materials are clean sands. Progressing upstream the dominant materials quickly become fine sands-silt-clay mixtures. The trenches of the upper reaches of the North Bay, Salt River, and sloughs contain relatively more of the fine sands, while the walls of the trenches contain even greater amounts of clay and decomposing fine organic material.

FIGURE 39

Substrate Distribution in the Eel River Estuary


Clay
Silt
Fine Sands
Medium Sands
Fine Gravel
Coarse Gravel
Small Cobbles
McNulty Slough
Hawk Slough
Slough
Quill Slough
Seven Mile Slough
Cannibal Road
LOLETA
U.S. 101
Dungan Slough
Dungan Pool
Fulmor Pool
riffle
riffle
Fernbridge
Fern Pool
Singley Pool
Crab Park
Cock Robin Island
PACIFIC OCEAN
Morgan Slough
Cutoff Slough
Salt River
FERNDALE

Nutrients

As with the other parameters measured, the nutrient concentrations were variable with the station, tidal stage, and date of sampling (Table 3 and Appendix B). River flow must also affect the nutrient concentrations, but the data collected reflects only the low river flow months.

Nitrogen

The most important forms of nitrogen in water are nitrate, nitrite, ammonia, and organic nitrogen. All these forms are biochemically interconvertible and thus available for biological uptake. Nitrate is the principle form and is normally present in water in small quantities. Ammonia in water is produced by the deamination of organic nitrogen-containing compounds, the hydrolysis of urea, and the reduction of nitrate under anaerobic conditions. Organic nitrogen, the "organically bound nitrogen in the oxidation trinegative state", is present as proteins, peptides, amino acids, nucleic acids, urea, and other organic compounds (APHA 1975). The three forms of nitrogen measured - nitrate, organic, and ammonia - showed approximately equal variation between tides and sampling dates in the sloughs on the north and south sides of the estuary (Table 3). Nitrate appears to show increased concentrations as the summer progresses in the north sloughs, but this pattern is not evident for those on the south side (Appendix B).

In the main channel of the estuary, the concentration of nitrate nitrogen is low in the upper reaches that receive the freshwater flows (m-1), but increases dramatically at the mouth of the estuary (m-9). Ammonia concentrations in the main channel are similar to those found in the sloughs, while the organic nitrogen appears to be lower in the main channel. It is evident that the river contributes little nitrate and organic nitrogen to the estuary, at least during the low runoff months. Sources of nitrogen to the estuary include the ocean, sediment deposits in the estuary, irrigation waters, and dairy or agriculture processing waste water.

Phosphorus

Phosphorus occurs in natural waters as various forms of phosphate, including orthophosphate, condensed phosphates, and organically bound phosphates. The latter group includes soluble organics, detritus, and living organisms. Phosphates occur in bottom sediments as precipitated inorganic and organic compounds.

Both dissolved orthophosphate and total phosphate were measured. No apparent pattern in the occurrence of the various forms at the different stations exists. Both the north and south sloughs showed considerable variation in the concentrations present, with tide and sampling date. The mouth of the estuary showed more phosphates to be present than at the upper station (m-1) of the main channel, although the differences, due to the limited number of samples taken and the small concentrations of phosphate present, may not be significant. Of greater significance is the substantially higher phosphate concentrations found in the sloughs. This indicates that neither the river, at least during the low flow periods, nor the ocean are responsible for contributing the main stores of phosphate for primary productivity in the estuary. The sources for the phosphates in the sloughs are much the same as for the nitrogen: sediment deposits, irrigation waters, dairy or agriculture processing waste water, and runoff from feedlots and pastures.

Silica

Silica is the second most abundant element on earth, appearing as an oxide in rocks and minerals. Silica enters water, as silicate ion, colloids, or suspended particles, upon the degradation of silica-bearing rocks and minerals. The silica content of natural waters ranges from 1 to 30 ppm most commonly, to as high as over 1,000 ppm in some brackish waters and brines (APHA 1975). Biologically, silica is the necessary element for the formation of frustules in diatoms.

The data indicate that the silica content in the estuary is within the range most commonly encountered for both freshwater (1 to 30 ppm) and sea water (0.4 to 8.6 ppm, Hem 1959). Comparing the concentrations of silica dioxide measured at the mouth of the estuary (m-9) to that present at the other stations indicates that the sea is probably not the principal source of silica to the estuary. The principal sources are probably from river flow or recycling and solution from the estuary sediments.

Total Organic Carbon

Total organic carbon (TOC) is used mainly to give an indication of the organic loading of an aquatic system due to pollution, which includes treated and nontreated sewage discharge. In nonfiltered samples, the TOC includes measurement of the carbon present in living tissues, such as phytoplankton and zooplankton, in addition to organic contaminants.

The TOC values obtained from the estuary are indicative of nonpolluted surface water (George Gaston, DWR, Bryte Laboratory, pers. comm.). These values are within the range obtained from several California coastal streams of good quality water (DWR, Northern District, data files). Thus, it is apparent that the estuary is receiving good quality water low in organic contaminants. However, the low dissolved oxygen present at times during low tide, the smell of hydrogen sulfide gas, and the presence of black ooze at many locations in the sloughs indicates that there is an oxygen demand exerted due to the presence of organic materials which are brought in principally with agriculture and dairy waste waters, but possibly also with high river flows.

TABLE 3

SURFACE NUTRIENTS IN EEL RIVER ESTUARY - $(\frac{HT}{LT})$, mg/l

	Nitrate (N)	Organic Nitrate (N)	Ammonia (N)	Dissolved O-PO_4 (P)	Total PO_4 (P)	Silica $Si\ O_2$	TOC C
N-1	0.01-0.14 / 0.04-0.16	0.0-0.8 / 0.0-0.5	0.00-0.17 / 0.00-0.13	0.04-0.18 / 0.07-0.25	0.06-0.41 / 0.14-0.47	- / -	1.8-3.7 / -
N-2	0.03-0.22 / 0.02-0.21	0.0-0.2 / 0.0-0.1	0.00-0.12 / 0.00-0.11	0.02-0.04 / 0.03-0.08	0.02-0.14 / 0.07-0.16	1.3 / 2.6	1.6-2.4 / -
N-3	0.01-0.23 / 0.02-0.20	0.0-0.3 / 0.0-0.1	0.00-0.11 / 0.00-0.09	0.03-0.04 / 0.03-0.10	0.05-0.16 / 0.08-0.20	4.9 / 4.8	1.9-2.5 / -
N-4	0.04-0.17 / 0.02-0.12	0.0-0.2 / 0.0-0.1	0.00-0.19 / 0.00-0.18	0.02-0.06 / 0.04-0.16	0.04-0.17 / 0.12-0.32	5.2 / 3.8	2.4-2.6 / -
N-5	0.02-0.06 / -0.03	0.0-0.3 / -	0.00- / -	0.07 / -	0.07-0.17 / -0.12	0.8 / 2.4	2.2-3.0 / -
N-6	0.02-0.29 / 0.03-0.32	0.0-0.4 / 0.0-0.1	0.00-0.15 / 0.00-0.29	0.01-0.04 / 0.02-0.04	0.01-0.23 / 0.06-0.32	0.8 / 2.5	1.7-2.5 / -
S-1	0.01-0.17 / 0.05-0.45	0.0-0.2 / 0.0-0.4	0.00-0.15 / 0.00-0.24	0.03-0.05 / 0.08-0.13	0.04-0.20 / 0.15-0.50	11.0 / -	2.2-3.0 / -
S-2	0.03-0.23 / 0.00-0.13	0.0-0.1 / 0.0-0.1	0.00-0.16 / 0.00-0.10	0.01-0.04 / 0.02-0.09	0.02-0.10 / 0.06-0.40	4.6 / 5.5	1.6-4.6 / -
S-3	0.00-0.26 / 0.01-0.26	0.0-0.2 / 0.0-0.4	0.00-0.13 / 0.00-0.10	0.02-0.06 / 0.03-0.07	0.04-0.11 / 0.05-0.44	2.2 / 9.6	1.6-2.0 / -
S-4	0.01-0.28 / 0.01-0.10	0.0-0.2 / 0.0-0.1	0.00-0.09 / 0.00-0.18	0.02-0.05 / 0.02-0.05	0.07-0.20 / 0.08-0.20	2.2 / 6.8	1.5-1.8 / -
S-5	0.11-0.20 / 0.08-0.9	0.0-0.1 / 0.0-0.0	0.00-0.31 / 0.19-0.36	0.02-0.03 / 0.04-0.06	0.11-0.32 / 0.07-0.22	-	
M-1	0.01-0.02 / 0.01-0.02	0.0-0.0 / 0.0-0.0	0.05-0.15 / 0.05-0.15	0.00-0.00 / 0.00-0.00	0.00-0.05 / 0.00-0.05	-	
M-2	0.00- / -	0.0- / -	0.01- / -	0.00- / -	0.02- / -	-	
M-4	0.01- / -	0.0- / -	0.00- / -	0.01- / -	0.02- / -	-	
M-9	0.21 / 0.11	0.0 / 0.0	0.08 / 0.00	0.03 / 0.02	0.09 / 0.10	2.5 / -	

Aquatic Invertebrates

Aquatic invertebrates were found in all areas of the Eel River estuary (Table 4), but the region around Crab Park predominated in terms of total numbers and diversity of organisms. This region contained the most diverse habitat, ranging from exposed tidepools at low tide to boulders, old wooden pilings and driftwood, abundant intertidal plants (Ulva, Enteromorpha, Zostera), and sand bars.

By far the most diverse group collected was the athropods. All members of this group were present in large numbers except Pachygrapsus crassipes (lined shore crab) and Heptacarpus brevirostris (shrimp), which were both rare. Anisogammarus confervicolus was the most common amphipod in protected habitats (pilings, rocks, plants), while Corophium stimpsoni was the most common amphipod in the bottom muds of the lower estuary, and was particularly abundant in the riffle area between Singley and Fern pools. This riffle exhibited the greatest fluctuation in salinity, ranging from about 156 to 2,400 ppm, depending on the tidal stage and amount of river flow. The isopods and barnacles were all abundant in areas with suitable substrate (rocks, logs, pilings, attached aquatic plants, etc.). Crangon franciscorum (bay shrimp) was abundant in all areas of the estuary, and was even found in Fern Pool, where the EC was approximately 250 micromhos/cm. Hemigrapsus oregonensis (yellow shore crab) was common under rocks at Crab Park.

The largest and most significant arthropod in the Eel River estuary is Cancer magister (Dungeness crab). This species was found in all areas of the lower estuary, and as far upstream as Dungan Pool, where young-of-the-year were particularly abundant during October 1976 (Appendix C). Few young-of-the-year Dungeness crabs were caught in the hoop nets prior to October, possibly because (1) nets were inefficient for catching smaller crabs, which may be less active, or for other reasons, and/or (2) the larger crabs intimidated the smaller ones, keeping them away from the baited nets. Large numbers of Dungeness crab exuvia of small size found throughout the early summer months indicate that the estuary is important as a nursery area. Adult crabs were also abundant, and ranged in size up to 16.5 cm (6.5 inches) across the carapace.

TABLE 4

AQUATIC INVERTEBRATES
FROM THE EEL RIVER ESTUARY

Scientific Classification	Common Name	Collection Location
Phylum Annelida		
Class Oligochaeta		
Unidentified sp. 1	oligochaete worm	Crab Park
Unidentified sp. 2	oligochaete worm	omnipresent
Class Polychaeta		
Glycinde polygnatha	polychaete worm	Crab Park
Nereis procera	little pileworm	North Bay
Nereis zonata	polychaete worm	Crab Park
Polydora brachycephala	polychaete worm	Crab Park
Unidentified sp.	polychaete worm	Crab Park
Phylum Arthropoda, Class Crustacea		
Order Amphipoda		
Anisogammarus confervicolus	amphipod	omnipresent
Corophium stimpsoni	amphipod	omnipresent
Orchestoidea pugettensis	beach hopper	Crab Park
Unidentified sp.	amphipod	Crab Park
Order Decapoda		
Cancer magister	Dungeness Crab	omnipresent
Hemigrapsus oregonensis	yellow shore crab	Crab Park
Pachygrapsus crassipes	lined shore crab	Crab Park
Crangon franciscorum	bay shrimp	omnipresent
Heptacarpus brevirostris	shrimp	North Bay
Order Isopoda		
Dynamenella dilatata	aquatic pillbug	Crab Park
Idotea fewkesi	isopod	North Bay
Idotea wosnesenskii	olive green isopod	North Bay
Ligia pallasii	sea slater	Crab Park
Order Thoracica		
Balanus cariosus	rock barnacle	Crab Park
Balanus glandula	acorn barnacle	Crab Park
Phylum Ctenophora		
Pleurobrachia bachei	sea walnut comb jelly	omnipresent
Phylum Cnidaria		
Phialidium gregarium	gregarious jelly fish	omnipresent
Polyorchis haplus	jelly fish	Crab Park
Polyorchis penicillatus	red-eye jelly fish	North Bay

TABLE 4
(Continued)

Scientific Classification	Common Name	Collection Location
Phylum Echinodermata		
Eupentacta quinquesemita	white sea cucumber	Crab Park
Phylum Mollusca		
Class Bivalvia		
Mya arenaria	Atlantic soft-shelled clam	omnipresent
Mytilus edulis	edible mussel	Crab Park
Solen sicarius	pink clam	McNulty & Cutoff Sloughs
Class Cephalopoda		
Octopus sp.	octopus	Crab Park
Class Gastropoda		
Aplysiopsis smithi	shell-less snail	Crab Park
Dendronotus iris	giant nudibranch	Crab Park
Hermissenda crassicornis	opalescent nudibranch	North Bay
Littorina scutulata	periwinkle	Crab Park
Phylum Nemertea		
Emplectonema gracile	ribbon worm	Crab Park
Phylum Chordata		
Ammodytes hexapterus*	Pacific sandlance	North Sand Spit

* Vertebrata

In addition, post-larval stage (megalops) Dungeness crabs were observed to be plentiful at Crab Park in late April, 1977. The distribution of the Dungeness crab may be limited by two factors: (1) salinity, and (2) substrate size. The distribution of substrate size is related to water density, the greater the density the slower the ability of suspended particles to settle out. Since Dungan Pool contains water of greater density (higher salinity) than that from upstream, the finer particles are held in suspension for some distance after encountering the denser water. The result is that larger particles (coarse gravels) settle out of the water column at the head of Dungan Pool, but they do not become covered by the finer particles (sand, silt). The coarse gravels provide poor habitat for crabs in that they are not able to bury themselves so as to avoid predation by other organisms. This, coupled with wide variations in the salinity with rising and falling tides, may occlude the presence of the Dungeness crabs from the head of Dungan Pool and upstream.

The molluscs represent another group with many representatives found in the Eel River estuary. Octopus sp. was commonly found at Crab Park during the late summer of 1976. The gastropods Aplysiopsis smithi (shell-less snail) and Dendronotus iris (giant nudibranch) were relatively rare, while Hermissenda crassicornis (opalescent nudibranch) was fairly common amongst intertidal plants in the North Bay. Littorina scutulata (periwinkle) was abundant along with the barnacles Balanus cariosus and B. glandula, and Mytilus edulis (edible mussel) on old pilings and driftwood. Besides M. edulis, other bivalves include Solen sicarius (pink clam) a burrowing form somewhat limited in distribution in the estuary, and Mya arenaria (Atlantic soft-shelled clam). This clam is common in the estuary, though it does not occur in any great number. A bed of M. arenaria was located in 1975 in one of the small sloughs tributary to Cutoff Slough. Other than this, its presence is widely scattered. M. arenaria prefers areas of low salinity, and was previously much more abundant than it is now, as evidenced by the great number of empty shells exposed on mud flats at low tide in the North Bay. A fairly recent shift in the location of the estuary mouth (late 1960's) with greater salt water influence in the North Bay may have stressed the clam population, making it more susceptible to a variety of factors, including suffocation due to a period of higher than normal siltation, internal parasites, or disease. Predation may also have taken its toll. Recent signs of heavy predation by otter is evident in the Cutoff Slough area.

Polychaete annelids include Glycinde polygnatha, Nereis procera, Nereis zonata, Polydora brachycephala, and one unidentified species. Oligochaete annelids include two unidentified species. All annelids were found at or near Crab Park. The polychaetes were common, while the oligochaetes were abundant in the bottom muds.

Of the Cnidaria, Phialidium gregarium (gregarious jellyfish) and Pleurobrachia bachei (sea walnut comb jelly) were abundant and found drifting with the current in all areas of the lower estuary. Polyorchis haplus (jellyfish) and Polyorchis penicillatus (red-eye jellyfish) were rare and found only at or near Crab Park.

A single echinoderm, Eupentacta quinquesemita (white sea cucumber) was found at Crab Park in August 1976.

The nemerteans were represented by a single species, Emplectonema gracile (ribbon worm), that was common among rocks and other organisms on old pilings and driftwood.

Ammodytes hexapterus (Pacific sandlance), a chordate, was common in the sands of the North sand spit. Although a vertebrate, this species is included because it has not been previously reported from the Eel River estuary.

Not enough information has been obtained to relate the presence of a particular species with the environmental factors controlling its distribution in the estuary. However, a few noteworthy observations can be made.

The Eel River estuary provides a particularly harsh environment, with drastic fluctuations occurring on a twice daily basis for all physical parameters. The most radically fluctuating parameter, and one that greatly influences many of the other factors, is the tidal stage. During a low tide, many organisms may be exposed and susceptible to desiccation and predation by terrestrial forms. Also, the temperature and salinity of high tide pools may increase due to heating by the sun and evaporation. The tidal stage effects current direction in all parts of the estuary, allowing downstream flow during low tide, but causing a reversal of this flow during high tide. The alternating current direction may cause alternations in eroding and deposition of bottom materials. The degree of tidal mixing with estuary water is effected by the magnitude of the tide and surface runoff, and effects the EC, D.O., and pH patterns throughout the estuary.

The distribution of substrate types is highly variable within the Eel River estuary. While most of the bottom substrate is composed of sands, silt, and clay, interspersed are areas of rocky outcroppings, wooden pilings, and driftwood. Each type of substrate provides habitat for food, reproduction, and protection for a particular type of organism. Therefore, organisms are limited in their distribution in the estuary by the availability of suitable substrate.

The availability of food to a particular species is as limiting a factor as any previously mentioned. Many different forms can be found in the Eel River estuary. Plant life includes not only the larger algae and flowering plants (see Monroe and Reynolds, 1974), but also many microscopic forms. Periphyton is present wherever suitable substrate exists (rocks, pilings, other plants), while phytoplankton should be abundant in the nutrient-rich open water. Another abundant food source is organic detritus, either produced in the estuary, or carried in with surface runoff or tidal inflow. The organisms that graze on the plant life and those that sift the water and bottom muds for detritus in turn provide food for larger predators, such as crabs and fish.

The organisms inhabiting estuarine environments have developed physiological or behavioral adaptations enabling them to withstand the harsh environment. The barnacles are permanently attached to rocks, pilings, or driftwood, except in the first larval stage which is free-swimming. These organisms have calcareous plates which close tightly to avoid desiccation during low tide. During the flood tide, the organisms extend cirri to catch fine particles of suspended detritus and plankton.

The annelids found in the Eel River estuary prefer areas of sandy mud sediments, where they may build tubes of sand grains (oligochaetes) or simply burrow into the bottom muds (polychaetes). At least one polychaete, *Nereis zonata*, has been known to build membranous tubes either on the blades or roots of plants such as *Zostera* and *Enteromorpha*. Most of the annelids found feed by swallowing substrate more or less unselectively, while a few selectively seek organic detritus of plant and animal origin.

The amphipods form a group with diverse environmental requirements. *Anisogammarus confervicolus* is a nestler in algae and surfgrass. *Corphium stimpsoni* builds a tube that is attached to debris on the bottom substrate. *Orchestoidea pugettensis*, while remaining moist, avoids direct contact with estuary water. This organism retreats up the beach when the tide is outgoing. All these amiphods feed on bits of vegetable matter.

The isopods also form a group with diverse environmental requirements. *Ligia pallasii* prefers rocks or cliffs above the high tide mark, but still within the splash zone. *Idotea fewkesi* and *I. wasnesenskii* are as much at ease in the water as on shore. *Dynamenella dilatata* prefers the aquatic habitat, but can tolerate exposure by the receding tide for short periods. These isopods feed either on vegetable matter or other smaller animals, and provide an important link in the food chain.

Decapods can be found anywhere from the shoreline to below the low tide line. *Hemigrapsus oregonensis* and *Pachygrapsus crassipes* are both shore crabs. The former can be found under rocks exposed at low tide, while the latter prefers the upper intertidal rocky areas, to as high as the splash zone. The Dungeness crab and shrimps prefer the sandy substrate below the low tide mark. The Dungeness crab spends much of its time buried in the bottom sand, and separating sediment from the water entering its gills is a vital problem. These forms are carnivorous, feeding on pieces of flesh from dead animals, and some are quite aggressive.

The Ctenophora and Cnidaria are closely related groups, except that the Ctenophora have only the medusa stage, while the Cnidaria contain members with both the medusa and polyp stages. The medusae of the cnidarians have tentacles with stinging nematocysts. The ctenophorans contain tentacles with colloblasts (glue cells). Locomotion in the ctenophorans is achieved by movement of rows of ciliated platelets, the comb rows. The cnidarians locomotion is achieved by contraction and expansion of the bell. Members of both groups are predators, capturing planktonic organisms.

The white sea cucumber, _Eupentacta quinquesemita_, is most commonly found under rocks where it attaches itself with its long rows of tube feet. It feeds on bits of detritus caught with its tentacles.

Molluscs are represented in the Eel River estuary by clams, mussels, octopuses, limpets, snails, and nudibranchs. The clams and mussels secrete a shell in the form of two lateral valves, hinged dorsally. The mussels attach themselves to wood or rock with byssal threads, and must rely on tidal currents to bring food particles to them. The clam _Solen sicarius_ forms permanent burrows in mud or muddy sand in which it moves freely up and down. The clam _Mya arenaria_, on the other hand, burrows up to 30 cm (1 ft.) in mud and sand when young, but loses all power of digging in adult life. These bivalves all feed by filtering the water with cilia for detritus particles. _Octopus sp_. contains no shell or skeleton. It can move rapidly over sand or rocks by the use of its arms and suckers. In the water it propels itself swiftly backwards with powerful jets of water from its siphon tube. When disturbed, the octopus can discharge a dense fluid from its ink sac to confuse its attacker and escape. The octopus captures food, consisting largely of fish and crustaceans (crabs are a particular favorite), by darting out from among rocks and crevices. The periwinkle _Littorina scutulata_ inhabits the zone between high and low tides. It attaches itself to wooden pilings and rocks, but is particularly abundant among barnacles and mussels. This snail scrapes periphyton from the substrate and other organisms with the use of its radula. Its movement seems to be triggered by the surge of the tide. When the tide is out, the organism simply stops moving and seals the shell against the substrate. The shell-less snail, _Aplysiopsis smithi_, is usually found among algae such as Enteromorpha. Its feeding habits are similar to the periwinkles. The nudibranchs are primarily predators of sedentary or sessile invertebrates, such as hydroids, sea anemones, and sponges. _Dendronotus_ iris is usually found subtidally with sea anemones, on which they feed.

The nemertean ribbon worm is a small predator, and is often found in great numbers among barnacles and mussels on rocks and pilings. It ejects a probosus with sticky secretions or needlelike stylets to capture prey.

Periphyton

Aufwuch periphyton from the Eel River estuary contained representatives of three Phyla (Table 5). Cladophora represents the Phylum Chlorophyta (greens) and was found in McNulty Slough. The Phylum Cyanophyta (blue-greens) was represented by two genera, Stigonema, found at both Hawk and McNulty Sloughs, and Oscillatoria, found in Hawk Slough. Diatoms of the Phylum Chrysophyta were the most diverse group of organisms. Cocconeis, Gomphonema, Melosira, Navicula, Nitzschia, and Synedra were found in Hawk Slough. Amphiprora, Cymbella, Fragilaria, Gyrosigma, Surirella, and all those found in Hawk Slough except Cocconeis, were found in McNulty Slough. Synedra was the dominant genus, representing approximately 75 percent and 80 percent of the population at McNulty and Hawk sloughs, respectively. Navicula represented approximately 10 percent and 15 percent of the population at McNulty and Hawk sloughs, respectively. A similar group of organisms was found in Salt River and Cutoff Slough.

TABLE 5

AUFWUCH PERIPHYTON FROM THE EEL RIVER ESTUARY

Organism	Hawk Slough	McNulty Slough
Phylum Chlorophyta		
Cladophora	-	+
Phylum Chrysophyta		
Amphiprora	-	+
Cocconeis	+	-
Cymbella	-	+
Fragilaria	-	+
Gomphonenia	+	+
Gyrosignia	-	+
Melosira	+	+
Navicula	+	+
Nitzschia	+	+
Surirella	-	+
Synedra	+	+
Phylum Cyanophyta		
Oscillatoria	+	-
Stigonema	+	+

CONCLUSION

Periods of decreased river flow enlarge the proportion of the estuary habitat favored by stenohaline organisms preferring highly saline conditions. Conversely, as river flow increases in the fall, a greater proportion of the estuary becomes favorable to those stenohaline organisms preferring less saline conditions, while the area available to those preferring the more saline conditions decreases. Euryhaline organisms, tolerating a wide range of salinities, may range freely from the more saline lower reaches to the upper freshwater regions, regardless of the river flow.

The physical parameters (pH, D.O., turbidity, temperature) are of sufficient quality in most of the estuary to provide suitable conditions for estuarine life forms. These conditions are, however, affected by the amount of freshwater flow and tide stage.

The Eel River estuary has been shown to support a rich and highly diverse fauna, including both fish (Puckett 1977) and invertebrates. More studies to describe the fauna are likely to turn up even more species, although the most common and probably important species have already been found. Of more concern should be the interaction between the more important organisms with their biotic and abiotic environment. This is especially important should the natural regime of the Eel River estuary be modified. Before modification of the natural regime, it is necessary to determine the effects the modification will have on the physical parameters in the estuary. Tolerances of biota important in the estuarine food web to any planned changes should be determined with laboratory investigations. Lethal levels, as well as acclimation levels, for the entire life span - reproduction, egg, larvae, preadult, and adult - should be determined. But, before designing a laboratory program to evaluate any environmental change, it is essential to conduct field studies to determine the important food web components. It is necessary to determine the food organisms of the more desirable game species; it does little good to maintain optimum physical conditions for the desired game species if they have no food available.

Should any project ever be given consideration that would alter the natural regime of the Eel River estuary, and because of the great importance and uniqueness of estuaries, the following recommendations are made: 1. an intensive library research effort be made to determine what information is available concerning the physiological requirements of estuarine organisms, especially those found in the Eel River estuary; 2. distribution, quantification, and a food web analysis be made for the organisms present in the Eel River estuary; and 3. field and/or laboratory determinations be made to determine the tolerance levels of the organisms present in the Eel River estuary to D.O., pH, turbidity, EC, temperature, and interaction with other organisms. A great deal of attention has been given to the importance of the estuary to salmonids, but little information has been generated. Residence times and distribution within the estuary are only poorly known. Organisms important as fish food in the Eel River estuary have not been determined. The extent that the salmonids, as well as other fishes, utilize the estuary for feeding and undergoing the physiological adjustments for going from fresh to saline water, and vice versa, needs to be determined. Only after such investigations have been performed can the adverse effects associated with many human endeavors be kept to a minimum.

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APPENDIX A

PHYSICAL DATA FROM EEL RIVER ESTUARY

Upper McNulty Slough (n-1)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	10/12/76	1330		66	8.3	8.0	33500	37900	7
"	5/25/76	1250		70	9.5	8.2	34000	26000	9
"	7/27/76	1330		70	7.3	8.0	35000	37400	8
"	5/13/76	1230		63	8.9	8.1	23000	34400	11
"	8/19/75	1430		68	5.7	-	29500	31800	3
"	8/ 6/75	1100		64	4.8	-	28000	28500	7
"	7/22/75	1315		74	6.5	-	28500	31900	7
"	6/11/75	1400		68	7.9	-	21000	20800	7
"	5/28/75	1440		75	11.5	-	20500	-	-
"	5/13/75	1640		70	9.3	-	9000	8860	17
LT	10/13/76	0840		59	5.8	7.8	36000	40250	8
"	8/23/76	0700		65	3.0	7.4	29000	32900	8
"	7/28/76	0710		65	6.1	7.9	40000	44700	16
"	6/15/76	0810		60	4.2	7.4	-	40580	16
"	5/13/76	0600		60	6.4	7.9	25500	28300	14
"	8/19/75	0700		64	2.8	-	28000	29500	5
"	8/ 7/75	0740		62	4.0	-	35000	34500	7
"	7/24/75	0800		68	4.2	-	37000	35900	8
"	6/11/75	0815		65	-	-	30000	31250	9
"	5/28/75	0915		64	-	-	27000	26350	12

McNulty Slough (at mouth) (n-2)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	10/12/76	1440		56	9.1	8.2	44000	48600	5
"	8/25/76	1300		56	9.3	8.2	44000	47300	4
"	7/27/76	1315		52	10.1	8.1	45000	49300	6
"	6/15/76	1730	s	62	10.2	8.2	43000	43040	10
"	6/15/76	1730	ln	59	11.1	-	45000	-	-
"	5/13/76	1330		55	10.5	8.1	30000	37300	7
"	8/19/75	1340		59	7.7	-	48000	46500	8
"	8/ 5/75	1445		60	8.1	-	45500	44300	10
"	7/22/75	1430		63	8.2	-	46000	45700	13
"	6/11/75	1545		55	10.4	-	48000	46700	12
"	5/27/75	1545		64.5	9.8	-	21200	-	-
"	5/13/75	1420		62	9.6	-	20000	19450	16
"	5/21/74	1310	s	62	15.4	8.4	27000	32500	11
"	5/21/74	1310	0.5m	54	-	-	40000	-	-
"	5/21/74	1310	1.0m	54	-	-	51000	-	-
"	5/21/74	1310	2.0m	54	-	-	52000	-	-
"	5/21/74	1310	2.5m	54	-	-	52000	-	-
LT	10/13/76	0930		57	6.2	8.1	40000	44600	9
"	8/25/76	0830		66	5.5	7.8	37000	40200	11
"	7/28/76	0800		63	6.0	7.8	45000	44900	20
"	6/14/76	2055		62	9.1	8.2	-	40640	15
"	5/13/76	0700		59	8.2	8.0	36000	38000	22
"	8/19/75	0745		62	4.7	-	43500	44500	15
"	8/ 7/75	0845		59	5.5	-	45000	45200	21
"	7/23/75	1030		63	4.3	-	35500	43500	24
"	6/11/75	0900		62	-	-	36000	35600	40
"	5/28/75	1015		61	-	-	30000	29650	27
"	5/14/75	1200		-	-	-	16000	-	-
"	6/19/74	0655		-	-	-	-	36900	65
"	5/21/74	0830	s	59.5	8.9	8.3	33000	30850	34
"	5/21/74	0830	0.8m	59	-	-	-	-	-

Hawk Slough (at mouth) (n-3)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	10/12/76	1430		57	9.6	8.2	44000	47500	5
"	8/25/76	1305		56	8.5	8.2	44000	47300	4
"	7/27/76	1400		54	10.3	8.1	45000	48500	5
"	6/15/76	1720	s	51	8.2	8.2	50000	48450	6
"	6/15/76	1720	3m	53	8.1	-	35000	49280	15
"	5/13/76	1340		54	9.8	8.1	39000	42250	3
"	8/19/75	1350		62.5	7.8	-	45000	47100	10
"	8/ 5/75	1425		60	7.8	-	45000	43300	10
"	7/22/75	1445		60.5	8.6	-	48000	46300	14
"	6/11/75	1530		55	10.6	-	51000	49250	10
"	5/27/75	1525		60.5	11.0	-	46000	-	-
"	5/13/75	1455	s	61.5	9.8	-	23000	21300	15
"	5/13/75	1455	1m	-	-	-	34000	-	-
	5/13/75	1455	1.5m	-	-	-	29000	-	-
LT	10/13/76	0920		57	7.1	8.1	40000	44444	10
"	8/25/76	0815		66	5.9	7.8	37000	40200	10
"	7/28/76	0800		61	6.1	7.8	45000	45200	13
"	6/14/76	2050		63	8.9	8.2	-	40400	15
"	5/13/76	0715		60	9.4	8.2	34500	33600	15
"	8/19/75	0815		63.5	5.0	-	42500	44200	15
"	8/ 7/75	0850		59	5.2	-	45000	44700	21
"	7/23/75	1045		63	4.6	-	34500	40800	17
"	6/11/75	0900		61	-	-	38000	36700	38
"	5/28/75	1015		62	-	-	27000	26500	27
"	5/14/75	1200		-	-	-	16200	-	-
"	6/19/74	0800		-	-	-	-	19300	23

Quill Slough (n-4)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	10/12/76	1420		60	8.1	8.2	40500	44950	10
"	8/25/76	1320		64	7.5	7.9	37000	39400	9
"	7/27/76	1415		61	6.4	7.7	44000	42700	11
"	6/15/76	1710	s	65	8.2	8.1	40000	39840	14
"	6/15/76	1710	1m	63.5	7.9	-	38000	-	-
"	5/13/76	1350		57	10.1	8.1	31000	30150	4
"	8/19/75	1245		63	5.6	-	31500	44500	15
"	8/ 6/75	1135		60	5.8	-	45000	44600	12
"	7/22/75	1515		73	6.6	-	28500	43200	20
"	6/11/75	1430		63	7.5	-	32000	31400	23
"	5/28/75	1510		67	9.5	-	17500	-	-
"	5/13/75	1600		65	9.4	-	13750	13300	14
"	5/21/74	1345	s	64	11.0	8.4	21000	20700	11
"	5/21/74	1345	1m	63.5	-	-	23600	-	-
"	5/21/74	1345	2m	61.0	-	-	25000	-	-
LT	10/13/76	0910		58	7.3	8.1	40000	44444	12
"	8/25/76	0800		66	5.4	7.7	37000	38600	6
"	7/28/76	0830		63	4.5	7.6	45000	45500	14
"	6/14/76	2045		68	8.9	8.1	-	40040	21
"	5/13/76	0730		62	8.4	8.2	21000	21100	15
"	8/19/75	0815		63.5	5.0	-	42500	43000	10
"	8/ 6/75	0900		61	5.1	-	44500	43200	15
"	7/23/75	1100		67	4.7	-	44500	43100	18
"	6/11/75	0915		63	-	-	33000	32550	28
"	5/28/75	1025		64	-	-	25000	24500	25
"	5/14/75	0925		-	-	-	14500	-	-
"	6/19/74	0800		-	-	-	-	19300	23
"	5/21/74	0900	s	61.5	7.7	8.3	19100	20400	26
"	5/21/74	0900	0.8m	61	-	-	19100	-	-

7-Mile Slough (n-5)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	8/19/75	1230		66	4.8	-	45000	-	-
"	8/ 6/75	1145		65	4.9	-	44000	44300	6
"	7/22/75	1330		73.5	7.0	-	43000	42600	6
"	6/11/75	1415		66.5	8.1	-	28200	28950	10
"	5/28/75	1455		71	10.3	-	20000	-	-
"	5/14/75	1615		-	-	-	-	10650	9
"	5/13/75	1555		69	10.9		6450	13000	10
LT	8/19/75	0900		64.5	4.0	-	43000	-	-
"	8/ 7/75	0800		61.5	4.4	-	44000	43500	8
"	7/23/75	0940		68	5.8	-	25000	42700	5
"	6/11/75	1000		65	-	-	28500	29200	4
"	5/28/75	0940		63.5	-	-	20500	20250	10
"	5/14/75	0910		-	-	-	10800	-	-

Crab Park (n-6)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	10/12/76	1450		54	9.1	8.2	45000	49350	4
"	8/25/76	1345		56	9.6	8.2	45000	47700	2
"	7/27/76	1300		51	10.3	8.1	45000	49400	4
"	6/15/76	1645	s	51	9.7	8.2	50000	49590	2
"	6/15/76	1645	3m	51	10.9	-	45000	49630	5
"	5/13/76	1315		48	9.8	8.0	49000	48400	4
"	8/19/75	1310		52	9.0	-	51000	49800	2
"	8/ 5/75	1400		51	9.4	-	50000	49000	4
"	7/22/75	1540		55	9.5	-	33000	48600	16
"	6/11/75	1500		53	10.0	-	54000	50000	6
"	5/27/75	1605		51	10.5	-	52000	-	-
"	5/13/75	1520	s	62	9.7	-	18300	17850	16
"	5/13/75	1520	b	-	-	-	49000	-	-
"	5/21/74	1230	s	52	11.7	8.4	54000	48250	7
"	5/21/7	1230	1m	52	-	-	54000	-	-
"	5/21/74	1230	2m	52	-	-	54000	-	-
"	5/21/74	1230	3m	52	-	-	54000	-	-
LT	10/13/76	0940		54	8.5	8.1	43000	42300	2
"	8/25/76	0840		60	7.6	7.9	36000	38300	2
"	7/28/76	0845		59	7.7	7.8	45000	35700	4
"	6/14/76	2020		59	12.1	8.6	-	45420	7
"	5/13/76	0645		57	9.3	8.0	36500	38800	20
"	8/20/75	0800		57.5	6.9	-	41500	41700	9
"	8/ 7/75*	0830		56	7.2	-	39000	38900	10
"	7/23/75	1010		54	7.5	-	31500	46900	6
"	6/11/75	0850		61	-	-	37000	36350	56
"	5/28/75	1000		62	-	-	28000	7190	14
"	5/14/75	0900		-	-	-	17400	-	-
"	5/21/74	0610	s	58	11.0	8.2	36000	32400	45
"	5/21/74	0610	1m	58	-	-	36000	-	-

Upper Salt River (s-1)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab.	
								EC	Turb. (JTU)
HT	10/13/76	1445		59	9.3	8.2	38000	41150	4
"	8/25/76	1420		68	7.7	8.0	27000	28800	6
"	7/27/76	1530		67	9.0	7.9	35000	35500	8
"	6/15/76	1510	s	67	8.5	7.9	18000	18840	14
"	6/15/76	1510	1m	67	8.2	-	10000	-	-
"	5/14/76	1215		57	10.0	7.9	17500	17950	10
"	8/19/75	1030		63	5.8	-	27500	28200	7
"	8/ 6/75	1230		62.5	7.9	-	34000	33400	9
"	7/23/75	1600		70	7.9	-	28000	27800	11
"	6/10/75	1515		70	8.5	-	6500	7110	10
"	5/28/75	1710		70	8.7	-	1950	-	-
"	5/14/75	1530		60	8.8	-	2600	2700	34
"	5/22/74	1400	s	68	-	7.9	4500	4845	18
"	5/22/74	1400	1m	-	-	-	5500	-	-
"	10/17/74							35200	
LT	10/13/76	0950		57	5.8	7.8	30000	25900	4
"	8/26/76	0900		65	4.1	7.4	8600	9015	4
"	7/28/76	1000		65	8.6	7.7	14800	15700	3
"	6/14/76	1925		74	8.2	7.8	-	9485	16
"	5/14/76	0715		54	6.3	7.2	1225	1525	11
"	8/20/75	0845		63	5.5	-	15700	15900	7
"	8/ 6/75	0920		64	5.9	-	15100	16000	4
"	7/23/75	0910		68	7.2	-	21500	14100	4
"	6/12/75	0820		60.5	-	-	2700	3080	11
"	5/29/75	0940		66	-	-	765	788	15
"	5/22/74	0800		64	-	7.9	4000	5880	15
"	6/20/74	0900		-	-	-	-	24200	-

Cutoff Slough (at mouth) (s-2)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	12/13/76	1500		54	8.8	8.2	45000	48500	3
"	8/25/76	1440		59	9.2	8.1	44000	47250	1
"	7/27/76	1500		56	10.5	8.0	46000	48200	3
"	6/15/76	1540	s	55.5	10.2	8.2	24000	41580	6
"	6/15/76	1540	2m	51	10.0	-	36000	-	-
"	5/14/76	1240		57	9.8	7.9	18000	13000	2
"	8/19/75	1115		52	8.6	-	50000	48700	7
"	8/ 6/75	1300		54	9.3	-	52000	47700	6
"	7/23/75	1500		64	8.7	-	50000	42600	7
"	6/10/75	1345		64.5	8.9	-	17500	14200	4
"	5/28/75	1630		68	9.1	-	4100	-	-
"	5/14/75	1635	s	62	9.6	-	500	545	29
"	5/14/75	1635	1m & 2m	-	-	-	500	-	-
"	5/22/74	1345	s	62	11.4	8.4	20000	29200	6
"	5/22/74	1345	1m	-	-	-	38000	-	-
LT	10/13/76	1010		56	7.6	8.1	38000	40900	4
"	8/26/76	0800		64	6.3	8.2	34000	37600	16
"	7/28/76	0915		61	6.7	8.0	40000	41700	13
"	6/14/76	1950		61	11.4	8.5	-	40620	10
"	5/14/76	0815		53	9.1	7.9	21700	23000	6
"	6/20/74	1000		-	-	-	-	38200	16
"	5/22/74	0845		61	8.6	7.9	18500	18250	17

Salt River (above mouth of Cutoff Slough) (s-3)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	10/13/76	1450		54	9.9	8.2	45000	48900	3
"	8/25/76	1430		59	10.0	8.0	44000	47250	2
"	7/27/76	1510		54	10.1	8.0	45000	48600	4
"	6/15/76	1530	s	52	11.0	8.2	18000	49050	6
"	6/15/76	1530	1m	51	9.8	-	19000	-	-
"	5/14/76	1215		57	10.0	7.9	17500	30700	4
"	8/19/75	1100		52	8.2	-	50000	49500	6
"	8/ 6/75	1315		52	9.0	-	52000	49000	5
"	7/23/75	1445		56	9.1	-	50000	47900	7
"	6/10/75	1330		59.5	9.1	-	33000	32100	4
"	5/28/75	1615		68	9.1	-	3300	-	-
"	5/14/75	1623	s & 1m	62	9.7	-	280	290	32
"	5/22/74	1345	s	58	-	8.4	43000	37500	5
"	5/22/74	1345	1.5m	-	-	-	44000	-	-
LT	10/13/76	1000		56	8.0	8.1	38000	40700	4
"	8/26/76	0850		64	5.5	7.7	26000	28000	15
"	7/28/76	0915		64	6.5	7.8	33000	33700	38
"	6/14/76	1945		65	8.0	8.0	-	23000	12
"	5/14/76	0715		54	6.3	7.2	1225	5715	17
"	6/20/74	1015		-	-	-	-	25200	-
"	5/22/74	0830		63.5	10.7	7.8	6200	6335	18

Morgan Slough (s-4)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	10/13/76	1510		57	11.8	8.2	44500	47000	2
"	8/25/76	1400		60	9.8	8.2	43000	47100	1
"	7/27/76	1445		56	11.5	8.0	45000	48600	2
"	6/15/76	1550	s	55	8.4	8.2	43000	49500	4
"	6/15/76	1550	1m	54	9.1	-	38000	-	-
"	5/14/76	1250		53	9.6	8.0	33000	40300	6
"	8/19/75	1130		53	8.7	-	50000	48900	3
"	8/ 6/75	1430		55	11.6	-	51000	48800	4
"	7/23/75	1515		60	10.2	-	50000	47400	7
"	6/10/75	1410		59.5	9.6	-	42000	-	-
"	5/28/75	1645		69	9.2	-	4000	-	-
"	5/14/75	1700	s	62	9.6	-	850	930	28
"	5/14/75	1700	1m	-	-	-	850	-	-
"	5/22/75	1315	s	56	12.2	8.2	44000	39600	5
"	5/22/74	1315	1m	-	-	-	49000	-	-
"	5/22/74	1315	2m	-	-	-	51000	-	-
LT	10/13/76	1030		55	6.9	8.0	32000	44200	2
"	8/26/76	0720		59	4.5	7.8	34000	37100	4
"	7/28/76	0930		60	6.0	7.6	38000	40700	17
"	6/14/76	2000		65	10.0	8.2	-	38640	5
"	5/14/76	0745		54	9.5	7.8	12300	16750	9
"	8/20/75	0855		59	5.6	-	43500	44100	6
"	8/ 6/75	0900		60	6.1	-	41500	40700	4
"	7/23/75	0850		63	5.8	-	26000	35100	4
"	6/12/75	0800		59.5	-	-	16500	17000	7
"	5/29/75	0925		65	-	-	3400	3800	10
"	5/15/75	0845		-	-	-	800	-	-
"	5/22/74	0900		62	9.5	7.9	16500	16400	13

Salt River (at mouth) (s-5)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	10/13/76	1520		54	9.8	8.2	46500	49400	2
"	8/25/76	1445		58	8.2	8.1	44000	47250	1
LT	10/13/76	1015		55	8.5	8.1	41500	41200	1
"	8/25/76	0745		62	6.5	8.0	34000	36500	14

Fern Pool (m-1)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	8/31/76	1605		68	12.0	8.2	230		
"	6/29/76	1500		73	9.3	7.8	280		

Riffle Above Singley Pool (m-2)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	8/31/76	1615	s	66	9.7	7.9	4000	5620	1
"	6/29/76	1520	<1m	67	9.3	7.6	280	-	-
"	6/16/76	1730	s	67	10.0	8.2	260	-	-
LT	9/ 1/76	1120	s	64	7.8	7.5	625	946	1
"	6/28/76	1900	<1m	68	9.5	7.8	280	-	-

Riffle Above Dungan Pool (m-3)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	8/31/76	1625	s	66	10.0	7.9	8000	5300	1
"	8/31/76	1625	1m	64.4	10.9	7.9	19000	18100	1
"	8/31/76	1625	2m	64.4	-	-	24500	-	-
"	6/29/76	1530	s	69	9.3	7.8	280	-	-
LT	9/ 1/76	1120	s	64	7.8	7.5	625	1170	1
"	6/28/76	1845	1m	68	95	80	315	-	-

Dungan Pool (m-4)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	8/31/76	1640	s	64	9.2	7.9	13000	9170	1
"	8/31/76	1640	1m	62	-	-	28000	29300	1
"	8/31/76	1640	2m	62	-	-	30000	33100	1
"	8/31/76	1640	2.8m	62	8.5	7.9	34000	33800	1
"	6/29/76	1540	s	66	8.7	7.6	2400	-	-
"	6/29/76	1540	1m	66	-	-	3200	-	-
"	6/29/76	1540	2m	66	-	-	30000	-	-
"	6/29/76	1540	3m	64.5	12.0	8.0	36000	-	-
"	6/16/76	1745	s	67	10.0	8.2	750	-	-
"	6/16/76	1745	1m	67	-	-	5000	-	-
"	6/16/76	1745	2m	65	-	-	24000	-	-
"	6/16/76	1745	2.6m	65	-	-	29500	-	-
LT	9/ 1/76	1140	s	64	7.8	7.5	1900	1940	1
"	9/ 1/76	1140	1m	62.5	-	-	30000	22400	2
"	9/ 1/76	1140	2m	61.5	5.7	7.6	30000	36750	1
"	6/28/76	1915	s	70	9.5	7.9	600	-	-
"	6/28/76	1915	1m	66	-	-	33000	-	-
"	6/28/76	1915	2m	65	12.0	7.9	36000	-	-

Below Fulmor Pool (m-5)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	8/31/76	1715	s	58	9.0	7.9	37000	29300	1
"	8/31/76	1715	1m	57.5	-	-	40000	42800	2
"	8/31/76	1715	1.5m	57.5	8.4	8.0	40000	-	-
"	6/29/76	1610	s	66	10.0	7.9	18500	-	-
"	6/29/76	1610	1m	65	-	-	32000	-	-
"	6/29/76	1610	1.7m	63.5	10.5	8.0	33000	-	-
"	6/16/76	1800	s	65	9.8	8.1	8000	-	-
"	6/16/76	1800	1m	65	-	-	21000	-	-
"	6/16/76	1800	2m	64	-	-	27000	-	-
"	5/15/76	1200	s	62	-	-	8750	-	-
"	5/15/76	1200	1m	60	-	-	13000	-	-
"	5/15/76	1200	2m	60	-	-	12500	-	-
LT	9/ 1/76	1205	s	62	8.6	7.6	4500	6260	2
"	9/ 1/76	1205	0.8	60	-	-	30000	-	-
"	6/28/76	2015	s	64.5	10.5	7.9	9000	-	-
"	6/28/76	2015	1m	63	-	-	3000	-	-
"	5/13/76	1715	s	64	-	-	500	-	-

South Channel (m-6)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	8/31/76	1700	s	60	11.0	7.9	35000	35600	1
"	8/31/76	1700	1m	58	-	-	38000	41100	1
"	8/31/76	1700	1.8m	58	10.3	7.9	39000	41400	2
"	6/29/76	1550	s	66	9.0	7.9	20000	-	-
"	6/29/76	1550	1m	66	-	-	25000	-	-
"	6/29/76	1550	1.5m	65	9.2	7.9	28000	-	-
LT	9/ 1/76	1155	s	63	7.4	7.6	5700	5430	1
"	9/ 1/76	1155	0.8m	62	-	-	18000	-	-
"	6/28/76	1945	s	66	9.8	7.9	7000	-	-
"	6/28/76	1945	1m	66	-	-	23000	-	-

North Channel (m-7)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	8/31/76	1720	s	55	9.1	8.1	44000	42500	2
"	8/31/76	1720	1	54	-	-	45000	47700	2
"	8/31/76	1720	2	54	9.7	8.1	45000	48400	3
"	6/29/76	1620	s	63	9.1	8.0	35000	-	-
"	6/29/76	1620	1m	63	-	-	39000	-	-
"	6/29/76	1620	2m	55.5	8.2	8.0	45000	-	-
"	6/16/76	1815	s	61	11.5	8.3	33000	-	-
"	6/16/76	1815	1m	60	-	-	37000	-	-
"	6/16/76	1815	2m	53	-	-	42000	-	-
"	5/13/76	1200	s	59	-	-	21000	-	-
"	5/13/76	1200	1	53	-	-	45000	-	-
"	5/13/76	1200	2	50	-	-	45000	-	-
LT	9/ 2/76	1230	s	58	7.8	7.5	35000	38000	2
"	9/ 2/76	1230	1m	56	7.7	7.8	38000	39800	3
"	9/ 1/76	1220	s	58	8.4	7.7	34000	16000	2
"	9/ 1/76	1220	1m	54	7.9	8.0	45000	47000	4
"	6/28/76	2025	s	64.5	10.2	8.0	30000	-	-
"	6/28/76	2025	1m	54	-	-	40000	-	-
"	6/28/76	2025	2m	54	8.0	7.9	45000	-	-
"	5/13/76	1715	s	64	-	-	1200	-	-
"	5/13/76	1715	1	63	-	-	3600	-	-

West of Cock Robin Island (m-8)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	8/31/76	1740	s	53	8.8	8.2	47000	48400	2
"	8/31/76	1740	1m	53	-	-	47000	48550	2
"	8/31/76	1740	2m	52.5	-	-	47000	48550	2
"	8/31/76	1740	3m	52.5	8.8	8.2	47000	48550	4
"	6/29/76	1630	s	56	7.5	8.1	46000	-	-
"	6/29/76	1630	1m	56	-	-	47000	-	-
"	6/29/76	1630	2m	54	-	-	47000	-	-
"	6/29/76	1630	2.5m	52	7.0	8.2	47000	-	-
"	6/16/76	1830	s	56	11.0	8.2	42000	-	-
"	6/16/76	1830	1m	54	-	-	48000	-	-
"	6/16/76	1830	2m	50	-	-	49000	-	-
LT	9/ 2/76	1250	s	59	8.6	7.7	22000	23500	2
"	9/ 2/76	1250	1m	56	9.0	8.0	41000	43900	3
"	9/ 1/76	1240	s	59	8.0	7.9	28500	28850	2
"	9/ 1/76	1240	0.9	56	-	-	40000	-	-
"	6/29/76	0845	s	57.5	8.0	7.9	30000	-	-
"	6/29/76	0845	1m	57	-	-	33000	-	-
"	5/13/76	1715	s	63	-	-	8500	-	-
"	5/13/76	1715	1m	57	-	-	36000	-	-
"	5/13/76	1715	2m	51.5	-	-	47500	-	-

Mouth of Estuary (m-9)

Tide	Date	Time	Depth (m)	Temp. (°F)	D.O. ppm	pH	EC umhos/cm	Lab. EC	Lab. Turb. (JTU)
HT	8/31/76	1750	s	52.5	9.1	8.2	47500	48800	4
"	8/31/76	1750	1	52	-	-	47500	48750	3
"	8/31/76	1750	2	52	-	-	47500	48650	3
"	8/31/76	1750	3	52	-	-	47500	48700	3
"	8/31/76	1750	3.5	52	-	-	47500	-	-
"	6/29/76	1645	s	54	8.1	8.2	48000	-	-
"	6/29/76	1645	1	54	-	-	49000	-	-
"	6/29/76	1645	2	53	-	-	49000	-	-
"	6/29/76	1645	3	53	-	-	49000	-	-
"	6/29/76	1645	4	52	-	-	49000	-	-
"	6/16/76	1845	s	49	8.9	8.1	52000	-	-
"	6/16/76	1845	1	49	-	-	52000	-	-
"	6/16/76	1845	2	49	-	-	52000	-	-
"	6/16/76	1845	3	49	-	-	52000	-	-
LT	9/ 2/76	1310	s	58	8.8	8.0	38000	39900	2
"	9/ 2/76	1310	1m	55	8.8	8.2	43000	45700	2
"	9/ 2/76	1310	2m	54	8.8	8.3	45000	46600	2
"	9/ 2/76	1310	3m	54	8.8	8.3	45000	47100	2
"	9/ 2/76	1310	4m	54	8.8	8.3	45000	47200	2
"	9/ 2/76	1310	5m	54	8.8	8.3	45000	47600	2
"	9/ 2/76	1310	6m	54	8.8	8.3	45000	47600	2
"	9/ 2/76	1310	7m	54	8.8	8.3	45000	47800	2
"	9/ 1/76	1250	s	52	9.9	8.2	47000	49000	3
"	9/ 1/76	1250	1	52	-	-	47000	49000	4
"	9/ 1/76	1250	2	52	-	-	47000	49000	4
"	9/ 1/76	1250	3	52	9.5	8.2	47000	49000	3
"	6/29/76	0900	s	61	7.3	7.8	30000	-	-
"	6/29/76	0900	1	59	-	-	35000	-	-
"	6/29/76	0900	2	58	-	-	38000	-	-
"	6/29/76	0900	3	57	-	-	39000	-	-
"	6/29/76	0900	4	57	6.0	7.8	40000	-	-

APPENDIX B

NUTRIENT DATA FROM EEL RIVER ESTUARY

Upper McNulty Slough (n-1)

Tide	Date	Time	Nitrate	Organic Nitrate	Ammonia	Ammonia and Organic Nitrogen	Dissolved Orthophosphate	Total Phosphorus	Silica ($Si\ O_2$)	T.O.C.
HT	10/12/76	1230	0.14	0.8	0.17		0.18	0.41		
"	8/25/76	1150	0.02	0.8	0.04		0.17	0.41		
"	7/27/76	1330	0.03	0.0	0.00		0.08	0.40		
"	8/ 6/75	1100	0.01			0.3		0.16		
"	7/22/75	1315	0.07			0.4		0.16		
"	6/11/75	1400	0.02			0.5		0.06		3.7
"	5/28/75	1440	0.03	0.5	0.00		0.04	0.07		1.8
LT	10/13/76	0730	0.16	0.2	0.13		0.14	0.34		
"	8/25/76	0600	0.04	0.5	0.00		0.25	0.47		
"	7/28/76	0710	0.06	0.0	0.00		0.09	0.14		
"	6/15/76	0810	0.06	0.0	0.00		0.07	0.20		

McMulty Slough (at Mouth) (n-2)

Tide	Date	Time	Nitrate	Organic Nitrate	Ammonia	Ammonia and Organic Nitrogen	Dissolved Orthophosphate	Total Phosphorus	Silica ($Si\ O_2$)	T.O.C.
HT	10/12/76	1340	0.22	0.0	0.06		0.04	0.14		
"	8/25/76	1200	0.10	0.0	0.12		0.02	0.02		
"	7/27/76	1315	0.21	0.0	0.00		0.04	0.09		
"	7/22/75	1430	0.10			0.2		0.09		2.4
"	6/11/75	1545	0.03			0.1		0.08		1.6
"	5/27/75	1545	0.10	0.2	0.02		0.04	0.07		2.2
"	5/21/74	1310	0.02			0.5		0.14	1.3	6.0
LT	8/13/76	0830	0.17	0.0	0.11		0.05	0.16		
"	7/28/76	0800	0.06	0.0	0.02		0.08	0.15		
"	6/14/76	2055	0.02	0.1	0.00		0.03	0.07		
"	8/ 5/75	1445	0.21			0.2		0.10		
"	5/21/74	0830	0.04			0.7		0.13	2.6	9.0

Hawk Slough (at mouth) (n-3)

Tide	Date	Time	Nitrate	Organic Nitrate	Ammonia	Ammonia and Organic Nitrogen	Dissolved Orthophosphate	Total Phosphorus	Silica (Si O_2)	T.O.C.
Ht	10/12/76	1330	0.23	0.0	0.10		0.03	0.15		
"	8/25/76	1205	0.07	0.0	0.11		0.03	0.16		
"	7/27/76	1350	0.21	0.0	0.00		0.04	0.07		
"	7/22/75	1445	0.11			0.2		0.08		2.4
"	6/11/75	1530	0.01			0.2		0.08		1.9
"	5/27/75	1525	0.14	0.3	0.00		0.03	0.05		2.5
"	5/21/74	1330	0.02			0.5		0.06	4.9	
LT	10/13/76	0820	0.15	0.1	0.08		0.06	0.17		
"	8/25/76	0715	0.10	0.0	0.09		0.10	0.20		
"	7/28/76	0800	0.09	0.0	0.00		0.06	0.18		
"	6/14/76	2050	0.02	0.1	0.00		0.03	0.08		
"	8/ 5/75	1425	0.20			0.2		0.10		
"	5/21/74	0845	0.03			0.8		0.16	4.8	

Quill Slough (n-4)

Tide	Date	Time	Nitrate	Organic Nitrate	Ammonia	Ammonia and Organic Nitrogen	Dissolved Orthophosphate	Total Phosphorus	Silica (Si O_2)	T.O.C.
HT	10/12/76	1320	0.16	0.0	0.19		0.06	0.13		
"	8/25/76	1220	0.08	0.0	0.19		0.06	0.12		
"	7/27/76	1415	0.13	0.0	0.00		0.06	0.14		
"	8/ 6/75	1135	0.17			0.3		0.17		
"	7/22/75	1515	0.09			0.1		0.12		
"	6/11/75	1430	0.06			0.3		0.13		2.4
"	5/28/75	1510	0.04	0.2	0.02		0.02	0.04		2.6
"	5/21/74	1345	0.03			0.5		0.08	5.2	6.0
LT	10/13/76	0810	0.12	0.1	0.07		0.11	0.22		
"	8/25/76	0700	0.04	0.0	0.18		0.16	0.32		
"	7/28/76	0830	0.05	0.0	0.02		0.08	0.19		
"	6/14/76	2045	0.02	0.0	0.00		0.04	0.12		
"	5/21/74	0900	0.05			0.8		0.15	3.8	

Seven Mile Slough (n-5)

Tide	Date	Time	Nitrate	Organic Nitrate	Ammonia	Ammonia and Organic Nitrogen	Dissolved Orthophosphate	Total Phosphorus	Silica ($Si O_2$)	T.O.C.
HT	8/ 6/75	1145	0.06			0.2		0.17		
"	7/22/75	1330	0.03			0.4		0.12		
"	6/11/75	1415	0.03			0.2		0.07		3.0
"	5/28/75	1455	0.02	0.3	0.00		0.07	0.10		2.2
"	5/21/74	1245	0.03			0.2		0.12	0.8	6.0
LT	5/21/74	0815	0.03			0.4		0.12	2.4	5.0

Crab Park (n-6)

Tide	Date	Time	Nitrate	Organic Nitrate	Ammonia	Ammonia and Organic Nitrogen	Dissolved Orthophosphate	Total Phosphorus	Silica ($Si O_2$)	T.O.C.
HT	10/12/76	1350	0.27	0.1	0.08		0.04	0.23		
"	8/25/76	1245	0.08	0.0	0.15		0.01	0.01		
"	7/27/76	1300	0.12	0.0	0.00		0.02	0.08		
"	6/11/75	1500	0.06			0.4		0.07		1.7
"	5/27/75	1605	0.29	0.4	0.01		0.04	0.07		2.5
"	5/21/74	1230	0.02			0.5		0.13	0.8	
LT	10/13/76	0840	0.19	0.1	0.09		0.04	0.12		
"	8/25/76	0740	0.06	0.0	0.29		0.04	0.12		
"	7/28/76	0845	0.07	0.0	0.00		0.04	0.09		
"	6/14/76	2020	0.03	0.0	0.00		0.02	0.09		
"	8/ 5/75	1400	0.32			0.0		0.06		
"	7/22/75	1540	0.13			0.2		0.12		2.1
"	5/21/74	0610	0.04			0.6		0.32	2.5	6.0

Upper Salt River (s-1)

Tide	Date	Time	Nitrate	Organic Nitrate	Ammonia	Ammonia and Organic Nitrogen	Dissolved Orthophosphate	Total Phosphorus	Silica (SiO_2)	T.O.C.
HT	10/13/76	1345	0.17	0.1	0.11		0.03	0.13		
"	8/24/76	1315	0.06	0.0	0.15		0.05	0.13		
"	7/27/76	1530	0.05	0.0	0.03		0.05	0.10		
"	5/14/76	1215	0.05	0.02	0.00		0.04	0.08		
"	8/ 6/75	1230	0.06			0.3		0.10		
"	7/23/75	1600	0.01			0.6		0.12		
"	6/10/75	1515	0.04			0.3		0.16		2.2
"	5/28/75	1710	0.03	0.2	0.04		0.03	0.04		3.0
"	5/22/74	1400	0.02			0.9		0.20	11.0	20.0
LT	10/14/76	0800	0.45	0.4	0.24		0.12	0.19		
"	8/26/76	0800	0.30	0.4	0.23		0.13	0.50		
"	7/28/76	0915	0.05	0.0	0.01		0.09	0.15		
"	6/14/76	1925	0.22	0.01	0.06		0.03	0.18		

Cutoff Slough (at mouth) (s-2)

Tide	Date	Time	Nitrate	Organic Nitrate	Ammonia	Ammonia and Organic Nitrogen	Dissolved Orthophosphate	Total Phosphorus	Silica (SiO_2)	T.O.C.
HT	10/13/76	1400	0.18	0.0	0.14		0.04	0.10		
"	8/25/76	1335	0.10	0.0	0.16		0.03	0.10		
"	7/29/76	1500	0.21	0.0	0.00		0.03	0.06		
"	5/14/76	1300	0.04	0.0	0.00		0.02	0.02		
"	8/ 6/75	1300	0.23			0.1		0.08		
"	7/23/75	1500	0.08			0.1		0.08		2.0
"	6/10/75	1345	0.06			0.2		0.06		1.6
"	5/28/75	1630	0.03	0.1	0.00		0.01	0.02		4.6
"	5/22/74	1330	0.02			0.3		0.04	4.6	10.0
LT	10/14/76	0910	0.13	0.0	0.10		0.07	0.18		
"	8/26/76	0705	0.02	0.0	0.08		0.09	0.40		
"	7/28/76	0915	0.00	0.1	0.07		0.04	0.24		
"	6/14/76	1955	0.05	0.0	0.00		0.03	0.06		
"	5/14/76	0815	0.03	0.0	0.00		0.02	0.08		
"	5/22/74	0845	0.02			0.5		0.09	5.5	3.0

Salt River (above mouth of Cutoff Slough) (s-3)

Tide	Date	Time	Nitrate	Organic Nitrate	Ammonia	Ammonia and Organic Nitrogen	Dissolved Orthophosphate	Total Phosphorus	Silica ($Si\ O_2$)	T.O.C.
HT	10/13/76	1350	0.21	0.0	0.04		0.05	0.11		
"	8/25/76	1330	0.11	0.0	0.13		0.02	0.04		
"	7/27/76	1515	0.22	0.0	0.00		0.03	0.07		
"	5/14/76	1230	0.19	0.0	0.00		0.03	0.04		
"	8/ 6/75	1315	0.26			0.0		0.07		
"	7/23/75	1445	0.13			0.2		0.08		2.0
"	6/10/75	1330	0.16			0.2		0.07		1.7
"	5/28/75	1615	0.02	0.2	0.00		0.06	0.07		1.6
"	5/22/74	1345	0.00			0.3		0.07	2.2	6.0
LT	10/14/76	0900	0.13	0.1	0.06		0.04	0.09		
"	8/26/76	0700	0.26	0.1	0.07		0.07	0.22		
"	7/28/76	0930	0.07	0.0	0.01		0.05	0.44		
"	6/14/76	1945	0.06	0.0	0.00		0.03	0.05		
"	5/14/76	0815	0.10	0.4	0.10		0.07	0.22		
"	5/22/74	0830	0.01			0.6		0.14	9.6	6.0

Morgan Slough (s-4)

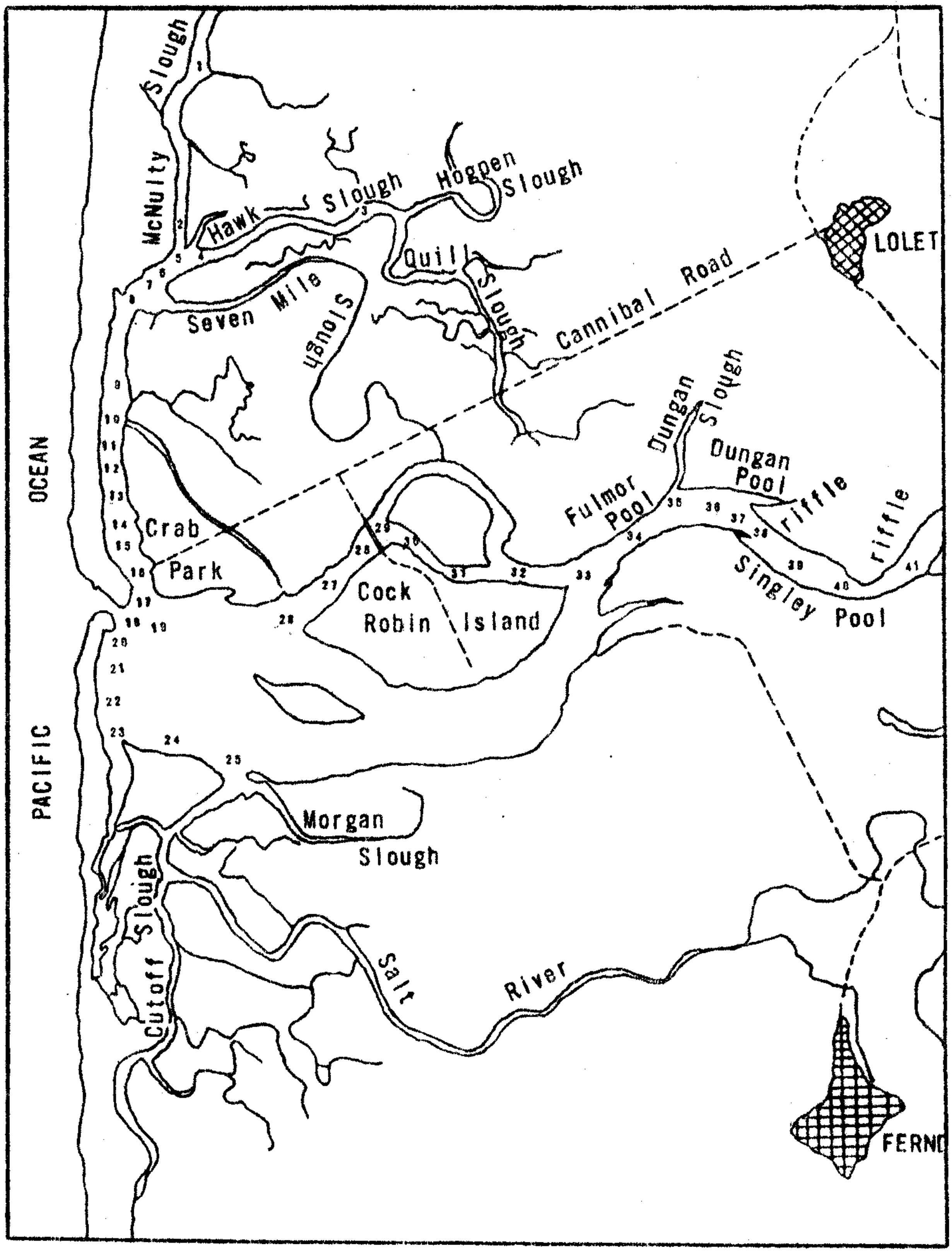
Tide	Date	Time	Nitrate	Organic Nitrate	Ammonia	Ammonia and Organic Nitrogen	Dissolved Orthophosphate	Total Phosphorus	Silica ($Si\ O_2$)	T.O.C.
HT	10/13/76	1410	0.12	0.0	0.07		0.05	0.22		
"	8/25/76	1300	0.11	0.0	0.09		0.03	0.05		
"	7/27/76	1500	0.18	0.0	0.00		0.03	0.07		
"	5/14/76	1300	0.28	0.0	0.00		0.03	0.07		
"	8/ 6/75	1430	0.17			0.0		0.07		
"	7/23/75	1515	0.07			0.4		0.08		
"	6/10/75	1410	0.16			0.2		0.07		1.5
"	5/28/75	1645	0.03	0.2	0.00		0.02	0.02		1.8
"	5/22/74	1315	0.01			0.2		0.07	2.2	
LT	10/14/76	0930	0.10	0.0	0.01		0.04	0.10		
"	8/26/76	0620	0.09	0.1	0.18		0.05	0.09		
"	7/28/76	0930	0.04	0.0	0.00		0.04	0.20		
"	6/14/76	2000	0.01	0.0	0.00		0.02	0.08		
"	5/14/76	0745	0.03	0.0	0.00		0.02	0.10		
"	5/22/74	0900	0.02			0.5		0.09	6.8	

	Tide	Date	Time	Nitrate	Organic Nitrate	Ammonia	Ammonia and Organic Nitrogen	Dissolved Orthophosphate	Total Phosphorus	Silica ($Si\ O_2$)	T.O.C.
						Salt River (at mouth) (s-5)					
	HT	10/13/76	1420	0.20	0.1	0.00		0.02	0.32		
	"	8/25/76	1345	0.11	0.0	0.31		0.03	0.11		
	LT	10/14/76	0915	0.09	0.0	0.36		0.04	0.07		
						Fern Pool (m-1)					
	LT	10/15/76	0900	0.02	0.0	0.05		0.00	0.05		
	"	8/19/76	1230	0.01	0.0	0.15		0.00	0.00		
						Riffle above Singley Pool (m-2)					
	HT	6/28/76	1900	0.00	0.0	0.01		0.00	0.02		
						Dungan Pool (m-4)					
	HT	5/13/76	1200	0.01	0.0	0.00		0.01	0.02		
						North Channel (m-7)					
Surface	HT	5/21/74	1500	0.01			0.0		0.03	9.2	
3M	"	5/21/74	1500	0.05			0.3		0.12	1.2	
Surface	LT	5/21/74	0930	0.00			0.0		0.03	9.0	
3M	"	5/21/74	0930	0.04			0.3		0.15	0.9	
						Mouth of Estuary (m-9)					
	HT	8/31/76	1650	0.21	0.0	0.08		0.03	0.09	2.5	
	LT	6/29/76	1700	0.11	0.0	0.00		0.02	0.10		

APPENDIX C

DISTRIBUTION OF THE DUNGENESS CRAB,
CANCER MAGISTER, IN THE EEL RIVER ESTUARY

Sample Locations



Size (cm)	Station 1 No.	Station 1 Date	Station 2 No.	Station 2 Date	Station 3 No.	Station 3 Date	Station 4 No.	Station 4 Date	Station 5 No.	Station 5 Date	Station 6 No.	Station 6 Date	Station 7 No.	Station 7 Date
3.6- 4.0							1	9/ 2/76	None					
4.1- 4.5			1	9/ 2/76			1	9/ 2/76						
4.6- 5.0			14	9/ 2/76										
5.1- 5.5			1	9/ 2/76										
5.6- 6.0			3	9/ 2/76										
6.1- 6.5			2	9/ 2/76										
6.6- 7.0			1	9/ 2/76										
7.1- 7.5	3	(6/16/76 (9/ 2/76											1	7/26/76
7.6- 8.0	1	6/16/76	3	9/ 2/76									1	7/26/76
8.1- 8.5	1	9/ 2/76	8	(6/16/76 (9/ 2/76	1	7/26/76								
8.6- 9.0	1	9/ 2/76	6	9/ 2/76	1	7/26/76	1	9/ 2/76						
9.1- 9.5	2	9/ 2/76	6	9/ 2/76	1	7/26/76								
9.6-10.0	1	9/ 2/76	7	9/ 2/76									1	7/26/76
10.1-10.5	1	9/ 2/76	5	9/ 2/76										
10.6-11.0			2	9/ 2/76							1	6/16/76		
11.1-11.5			3	9/ 2/76										
11.6-12.0			1	9/ 2/76										
12.1-12.5											1	6/16/76		
12.6-13.0	1	9/ 2/76	1	9/ 2/76										
13.1-13.5							1	9/ 2/76						
13.6-14.0			1	9/ 2/76	1	7/26/76								
14.1-14.5	3	9/ 2/76	1	9/ 2/76	1	6/16/76								
14.6-15.0	4	9/ 2/76	6	9/ 2/76	3	7/26/76					1	6/16/76		
15.1-15.5	1	9/ 2/76	7	9/ 2/76	1	6/16/76					1	7/26/76		
15.6-16.0														
16.1-16.5	1	9/ 2/76												

Size (cm)	Station 8 No.	Station 8 Date	Station 9 No.	Station 9 Date	Station 10 No.	Station 10 Date	Station 11 No.	Station 11 Date	Station 12 No.	Station 12 Date	Station 13 No.	Station 13 Date	Station 14 No.	Station 14 Date
3.6- 4.0														
4.1- 4.5														
4.6- 5.0														
5.1- 5.5														
5.6- 6.0											1	6/17/76		
6.1- 6.5														
6.6- 7.0														
7.1- 7.5														
7.6- 8.0														
8.1- 8.5														
8.6- 9.0														
9.1- 9.5														
9.6-10.0														
10.1-10.5														
10.6-11.0							1	6/17/76						
11.1-11.5			1	6/17/76	1	6/17/76								
11.6-12.0														
12.1-12.5			1	6/17/76					1	6/17/76				
12.6-13.0														
13.1-13.5														
13.6-14.0			1	6/17/76					1	6/17/76			1	6/17/76
14.1-14.5			1	6/17/76			3	6/17/76	2	6/17/76			1	6/17/76
14.6-15.0							3	6/17/76						
15.1-15.5	2	6/16/76	3	6/17/76			1	6/17/76	1	6/17/76	1	6/17/76	1	6/17/76
15.6-16.0	1	6/16/76	1	6/17/76										
16.1-16.5														

Size (cm)	Station 15 No.	Station 15 Date	Station 16 No.	Station 16 Date	Station 17 No.	Station 17 Date	Station 18 No.	Station 18 Date	Station 19 No.	Station 19 Date	Station 20 No.	Station 20 Date	Station 21 No.	Station 21 Date
3.6- 4.0														
4.1- 4.5														
4.6- 5.0														
5.1- 5.5														
5.6- 6.0														
6.1- 6.5														
6.6- 7.0														
7.1- 7.5														
7.6- 8.0														
8.1- 8.5														
8.6- 9.0									1	7/27/76				
9.1- 9.5			1	6/17/76			1	7/26/76					2	7/26/76
9.6-10.0							1	6/17/76						
10.1-10.5							1	7/26/76	1	7/27/76			2	7/26/76
10.6-11.0														
11.1-11.5					1	6/17/76					2	7/26/76		
11.6-12.0	1	6/17/76									1	7/27/76		
12.1-12.5														
12.6-13.0														
13.1-13.5			1	6/17/76										
13.6-14.0							1	7/27/76						
14.1-14.5									1	7/26/76	4	7/26/76	2	7/26/76
14.6-15.0	1	6/17/76	1	6/17/76										
15.1-15.5	4	6/17/76	2	6/17/76	2	6/17/76					1	7/27/76		
15.6-16.0											2	7/26/76		
16.1-16.5			1	6/17/76										

Size (cm)	Station 22		Station 23		Station 24		Station 25		Station 26		Station 27		Station 28	
	No.	Date	No.	Date	No.	Date	No.	Date	No.	Date	No.	Date	No.	Date
3.6- 4.0														
4.1- 4.5														
4.6- 5.0											1	6/29/76		
5.1- 5.5														
5.6- 6.0														
6.1- 6.5														
6.6- 7.0														
7.1- 7.5														
7.6- 8.0														
8.1- 8.5									1	6/29/76				
8.6- 9.0							1	7/27/76						
9.1- 9.5	1	7/26/76											1	6/29/76
9.6-10.0														
10.1-10.5	1	7/26/76												
10.6-11.0									1	6/29/76				
11.1-11.5														
11.6-12.0														
12.1-12.5													1	6/29/76
12.6-13.0														
13.1-13.5														
13.6-14.0			1	7/27/76										
14.1-14.5					1	7/27/76							1	6/29/76
14.6-15.0			2	7/27/76	1	7/27/76	2	7/27/76			1	6/29/76		
15.1-15.5	1	7/27/76			2	7/27/76	1	7/27/76	2	6/29/76	2	6/29/76	1	6/29/76
15.6-16.0					1	7/27/76			1	6/29/76			1	6/29/76
16.1-16.5			1	7/27/76					1	6/29/76				

Size (cm)	Station 29		Station 30		Station 31		Station 32		Station 33		Station 34		Station 35	
	No.	Date	No.	Date	No.	Date	No.	Date	No.	Date	No.	Date	No.	Date
3.6- 4.0							None		1	10/13/76				
4.1- 4.5														
4.6- 5.0											1	10/13/76		
5.1- 5.5									5	10/13/76	3	10/13/76	3	10/13/76
5.6- 6.0									11	10/13/76	12	10/13/76	7	10/13/76
6.1- 6.5									3	10/13/76	8	10/13/76	6	10/13/76
6.6- 7.0			1	7/27/76					5	10/13/76			6	10/13/76
7.1- 7.5	1	7/27/76									11	10/13/76	6	10/13/76
7.6- 8.0			1	7/27/76	1	7/27/76					5	10/13/76	6	10/13/76
8.1- 8.5			1	7/27/76					2	10/13/76	4	10/13/76	3	10/13/76
8.6- 9.0											3	10/13/76		
9.1- 9.5			1	7/27/76							2	10/13/76	1	10/13/76
9.6-10.0														
10.1-10.5	1	7/27/76												
10.6-11.0			1	7/27/76										
11.1-11.5														
11.6-12.0														
12.1-12.5														
12.6-13.0														
13.1-13.5														
13.6-14.0	1	7/27/76			1	7/27/76								
14.1-14.5														
14.6-15.0														
15.1-15.5	1	7/27/76	1	7/27/76										
15.6-16.0														
16.1-16.5														

Size (cm)	Station 36		Station 37		Station 38		Station 39		Station 40		Station 41	
	No.	Date	No.	Date	No.	Date	No.	Date	No.	Date	No.	Date
3.6- 4.0			None		None		None		None		None	
4.1- 4.5												
4.6- 5.0												
5.1- 5.5												
5.6- 6.0												
6.1- 6.5	1	10/13/76										
6.6- 7.0												
7.1- 7.5	1	10/13/76										
7.6- 8.0	3	10/13/76										
8.1- 8.5	2	10/13/76										
8.6- 9.0												
9.1- 9.5												
9.6-10.0												
10.1-10.5												
10.6-11.0												
11.1-11.5												
11.6-12.0												
12.1-12.5												
12.6-13.0												
13.1-13.5												
13.6-14.0												
14.1-14.5												
14.6-15.0												
15.1-15.5												
15.6-16.0												
16.1-16.5												